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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2619.] LONDON: FRIDAY, MARCH 10, 1916. [Registered at the General Post Office as a Newspaper.] [PRICE...6d. BY INLAND POST..8d.

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4th March, 1916. D 743

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India Office, London.
1st March, 1916. D 744

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By G. G. M. HARDINGHAM,
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GRINDING-MACHINES.—No. XXI.

By JOSEPH HORNER.

CONTINUING our descriptions of examples of modern designs of wheel-heads, we give in Fig. 301, on Plate XX., a transverse section through one of the Brown and Sharpe plain grinding-machines taken along the plane of the grinding-wheel axis. To avoid referring back to this drawing at a later stage, we will briefly note now the other details shown, besides those of the wheel-spindle fitting. The spindle is parallel through both bearings. Wear is taken up by phosphor-bronze bushings, which are thrust along by nuts *a*, *a* that are screwed, not on the outsides of the bearings, as is usual, but on the ends of the boxes which enclose the bushings. The pressure of the nuts takes place on the plain ends of the bushings, which are shouldered down and undercut. The protection afforded against dust should presumably be perfect. The globular form of enclosing-box is similar to all the boxes of Brown and Sharpe design, the feature of which is their self-aligning property. Oil is supplied from above, flowing to the spring-supported felt pad below. The end thrust is taken against two washers *b*, *b*, which bear against spherical seats in the sleeve that is secured to the rear end of the hinder box. A closer fit than that which is afforded by plane-faced washers is the advantage claimed. The end is protected by the cap seen.

The pulley A is split in halves, to be interchangeable with those of other sizes, so that speeds can be readily altered. A permanent bush B encircles the shaft, having a flange recessed at one end, to receive one end of the pulley-boss, and a nut C at the other. When the latter is slackened back, the halves of the pulley can be removed and those of another size substituted and set up in position.

The wheel mounting is of the self-contained design, attached to the tapered end of the spindle and secured with an external nut. The wheel is gripped between the main plate and a washer, the opposed faces of which are undercut as a measure of safety.

The interest of the other details concerns the provision made for rapid hand travel of the wheel-slide D along its ways from one extreme to the other. The object of this is twofold : to be able to adjust the wheel rapidly when changing work that varies much in diameter, and to lubricate the slideways after the machine has been standing idle for several hours—as, for instance, through a night. Unless the parts move with perfect freedom fine adjustments are not practicable.

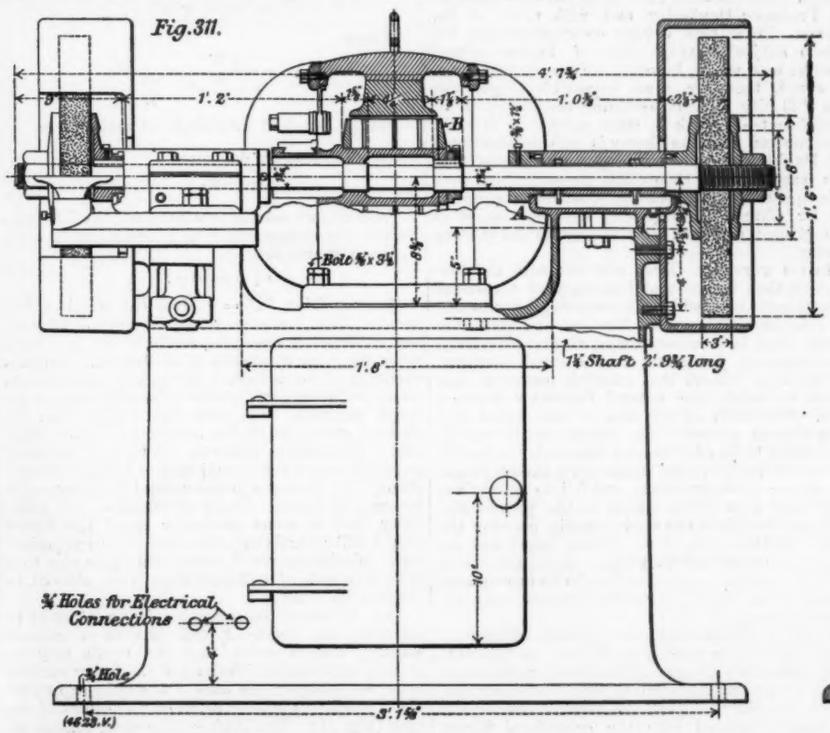
The travel of the wheel-slide is accomplished by the pinion E, at the upper end of the vertical shaft F, engaging with the rack G, which is screwed to the slide D. A clutch H is pinned to the shaft and engages with a similar clutch attached to the boss of a worm-wheel J. The wheel is turned by a worm K on a shaft which is controlled from the cross-feed hand-wheel (not shown) at the front of the machine. Below the vertical shaft F is a cam L on a horizontal shaft, which is turned by a lever at the front of the bed. When the cam is turned up it disengages the clutch H, so that the worm J becomes inoperative. The hand-wheel M, being now turned, operates a pinion on its shaft which engages a rack N fixed on the stand, and so moves the slide D rapidly. When the cam L is dropped the clutches fall into engagement ready for the fine travel to proceed.

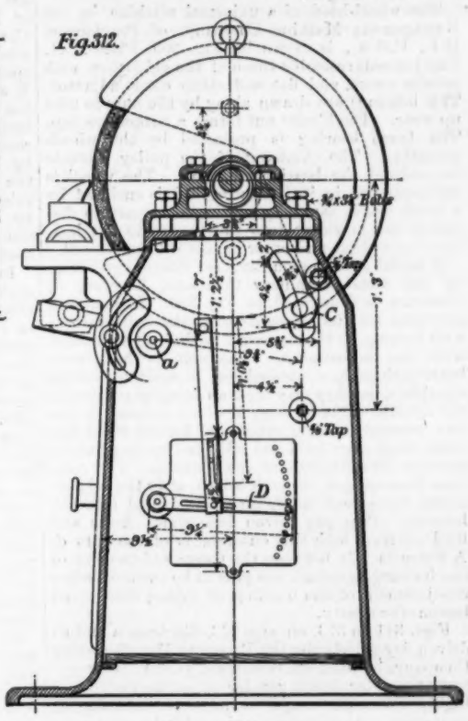
Another detail shown in this drawing is the tank and pump O for wet grinding. The pump, enclosed by the tank, is of the centrifugal type, and is driven by a belt on the pulley P at the top of the vertical shaft, to which it is directed over guide-pulleys Q. The deep troughs which surround the bed of the machine will also be noticed.

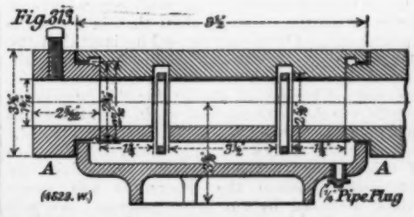
The wheel-head by the Cincinnati Grinding Company, of Cincinnati, Ohio, U.S.A., is shown by Fig. 302, Plate XX. The belt-pulley is located centrally ; the journal-bearings are parallel. Wear is taken up by drawing the split bushings lengthwise by the circular nuts *a*, *a*, screwed on the outsides of the bushings, and the pressure is relieved by pulling up the screws *b*. *b* tightly in the splits. End-thrust is taken up at the rear only. A lock-nut A is loosened with a prong key, and the thrust-screw B is drawn up to make the correct adjustment, and then the nut A is tightened. Felt pads and oil-grooves distribute the lubricant. The ends of the bearings are protected. The wheel when mounted is subject to end pressure only; it is of the self-contained design. An iron centre fits on the spindle-nose with a Woodruff key, being tightened with a flush-nut. The wheel is clamped between this and a circular washer screwed on the nose of the boss. The pressure is not taken over the entire faces, but on annular contacts only. The small space left between the wheel-plate and the front bearing for taking up wear is covered and protected by an extension of the front nut *a* into a groove in the wheel-boss. A strong guard surrounds the upper and hinder part of the wheel, and to this the jointed lubricating-pipe is attached. A registered cover is adjustable round the front part of the wheel. The worm-wheel drive to the pinion and rack is seen in the lower part of the figure.

The Bath Grinder Company, of Fitchburg, Mass., U.S.A., make wheel-heads of the design shown in Figs. 303 to 306, on Plate XXI. The spindle, of tool steel, runs in split bushes of phosphor bronze. The split occurs in three equidistant locations, as shown in Fig. 306, two being only partially through, and one right through. Tapered grub-screws in the latter (compare with Fig. 305) are the means by which fine adjustment is made, in conjunction with the longitudinal movement of the conical bushes, effected by the square-threaded nuts on the ends of each. During this movement the grub-screws are slackened, and are afterwards re-tightened just sufficiently to prevent the bushes from bearing too hard on the journal. The screws occupy slotted holes to permit of the endlong movements of the bushes. The holes through which these screws are tightened are closed with short grub-screws, as shown in Fig. 304. The journals are lubricated through holes in the main casting, closed with grub-screws. The oil passes through countersunk holes in the bushes, and is distributed from the felt pads round grooves cut in the journals. The countersunk holes are set eccentrically in relation to the feeding holes to permit of the longitudinal movements of the bushes. End play is taken up on the rear bearing only, between the rear face of the pulley and the face of the nut on the tail-pin. The grinding-wheel is self-contained on its mounting, which is fitted to the tapered end of the spindle with a Woodruff key and a sunk nut.

The V's seen in Fig. 303 are a peculiarity due to the method by which the wheel-head is mounted. It is moved vertically on a slide on the column of the machine through a range of 7 in. Its location







FIGS. 311 TO 313. MOTOR-DRIVEN DRY GRINDER; THE RANSOME MANUFACTURING COMPANY, OSHKOSH, WISCONSIN, U.S.A.

is effected by means of a vertical rod divided into sixteenths of an inch, and a micrometer divided into thousandths.

In the event of the fracture of wheels, safety is promoted by the employment of the protection-hood of sheet iron or steel, cast iron or cast steel. The present tendency is to make these much stronger than formerly, and to embrace a larger arc of the wheel. A slight hood is useless, because the momentum of a broken wheel will distort or fracture a weak covering. Cast iron is not so reliable as stout steel sheet, but a cast-iron hood is more easily made, and if well designed and of good thickness it is much better than no covering at all. The wheel-hood and water supply fitted by the Bath Grinder Company to their heads is seen in Figs. 307 and 308, Plate XXI. The water supply is directed by a nozzle to the wheel at the centre. The pipe can be adjusted through a split-boss, supported by the hood. The water supply can be regulated by the $\frac{3}{4}$-in. globe valve. The nose of the hood is hinged.

The wheel-head of a universal machine, by the Narragansett Machine Company, of Providence, R.I., U.S.A., is shown by Fig. 309, Plate XXI. The journals resemble those of the old lathes, with reverse cones, and flat and steep cones adjacent. The bearings are drawn along by the nuts to take up wear. The hinder nut forms a protective cap. The front bearing is protected by the wheel-mounting. The overhang of the pulley protects the ends of the bearings adjacent. The wheel is self-contained in its mounting. It is enclosed by a hood, which has a lip at its lower part to discharge the lubricant into the trough in the bed. The worm-drive and other details will be noticed.

A recent spindle-mounting, for internal grinding, by the Auto-Machinery Company, Limited, of Coventry, is illustrated in Fig. 310. It combines provision for the adjustment of the ball-bearings with locking, so that it would be difficult to tamper with the adjustment. The spindle has inner bearing-rings *a*, *a* pressed on it against locating shoulders, or they may form an integral portion of the spindle. The housing *b*, which encloses it, has two internal locating shoulders, against which the outer rings *c* are held and adjusted by ring-nuts *d*, screwed into the ends of the housing. The ring-nuts have flanges, through which, after the adjustments have been made, holes are drilled into the housing. Pins are driven into these holes and filed off flush with the outer faces of the nuts *d*. A space is left between the flange and the end of the housing to permit the pins to be sawn off when readjustment of the bearings or taking them apart becomes necessary.

Figs. 311 to 313, on page 223, illustrate a motor-driven dry grinder by the Ransome Manufacturing Company, of Oshkosh, Wisconsin, U.S.A. It represents the older bench-grinder in an improved and highly elaborated stage, mounted on an independent stand. It includes provision for the automatic regulation of speeds as the wheels wear down.

The spindle, $1\frac{9}{16}$ in. in diameter, of high-carbon steel, runs in very long parallel bearings, 9 in. long, the details of which are seen in Fig. 313. The lower part forms an oil well, distributing the oil by two rings of babbitt. Wear, which must be very slow, is taken up by closing the caps. The inner ends of the bearings are protected by means of collars A set with screws and grooved on the inner ends. The bodies of the wheel mountings are made to serve the same function.

The central armature B is wound on a spider, which is a press fit on the spindle. The starting-box, the switch, and non-arcing fuses are located in the stand beneath (Fig. 312). The motor is four-poled, shunt-wound, using direct current. The regulation of the speed of the grinding-wheel is effected through a roller-gauge C (Fig. 312), which, being set directly under the wheel, as the latter wears, moves the arm of the field rheostat in the base of the machine. The roller is adjusted in the curved slot in the plated portion of the wheel-guard, being moved by the handle pivoted round the centre *a*. The connecting-rod then moves the lever-arm D over the face of the rheostat, and so regulates the speed of the motor to suit the diameter of the wheel. If one wheel wears down faster than the other, the speed is regulated by the larger one. This machine takes a 5-horse-power motor.

The machine is mounted on a stand, the interior of which is utilised as a cupboard for the electrical control, which can be inspected on opening the door in the stand. The top of the base casting is faced to receive the spindle-bearing castings and the central casing, in three parts, which encloses the central motor, while there are facings at the sides to which the hoods are bolted.

ON THE WHIRLING SPEEDS OF LOADED SHAFTS.

By WILLIAM KERR, A.R.T.C.

(*Continued from page* 199.)

PART II. ON THE THEORY OF WHIRLING SPEEDS.

Explanatory.—In the endeavour to explain the disagreement which has been shown to exist between the theoretical and actual critical speeds of the 250-kw. turbine rotor, the present writer was led to a careful study of the leading papers on this subject; but nothing was found therein which would provide a satisfactory explanation. The methods of calculation which have been employed are in complete accordance with the investigations of Professor Dunkerley and with those of Dr. Chree. These two writers cover practically the whole subject, except that of higher critical speeds, with which, however, we are not concerned. It would, therefore, seem impossible to get over the difficulty without assuming the theory to be insufficient—or weak in some point. It is to be remembered that the theory is well substantiated by Dunkerley's extensive experiments, and that the results of his theoretical investigations were subsequently established—in a different manner—by Dr. Chree. Consequently any explanation of the present difficulty must not refute the existing theory.

In his work, Dr. Chree sets out with the conception that the natural frequency of transverse vibrations is reduced by the centrifugal forces due to rotation. This means that for any particular speed there is a corresponding natural frequency, the frequency decreasing as the speed increases. It naturally follows that whirling occurs at that speed at which the natural frequency becomes zero. The truth of this idea is established in a very elegant manner. The results are in accordance with those of Professor Dunkerley, obtained ten years earlier; but Dunkerley's investigations are rather more cumbrous, and fail to convey any very clear idea of the nature of the phenomena, although he points out a relationship between the lower limiting value of the critical speed and the frequency (when not rotating). This relationship has been stated by some writers to be merely accidental; but, in fact, it follows directly from Dr. Chree's theory.

In all the theoretical investigations which have been made by the various authorities on this subject, the effect of gravity has been neglected as being in general too small to merit consideration. It is to be admitted that the force of gravity will be small compared with the centrifugal forces. Also, it will not enter into the most general investigation of whirling speeds, since that involves the consideration of both vertical and horizontal shafts. But it seems to the present writer that the smallness of its effect has been too readily assumed (in the case of horizontal shafts) for the purpose of simplifying the mathematical work, with the result that its real effect has been completely overlooked.

It is on the results accruing from a consideration of this factor that we attempt to explain the differences between the theoretical and actual values disclosed by our investigations. We will now proceed with the general investigation, which, if correct, will be seen to constitute an extension of the theory as given by Dr. Chree. It is certainly correct to consider this factor, but sufficient courage to present the investigation is founded on the fact that the results provide an excellent explanation of our difficulties. The method of carrying out the investigation has obviously been inspired by Dr. Chree's paper,* but the analysis is somewhat more complete, embodying as it does certain factors which have been hitherto neglected. The result, while exhibiting Dr. Chree's idea quite clearly, shows also the additional point to which it is desired to draw attention.

MATHEMATICAL INVESTIGATION.

Before proceeding with the complete and somewhat complicated investigation, it might be best to give the following simple presentation of the idea which we are endeavouring to follow out. It serves to indicate the way in which the force of gravity is important. The desired result is not so attained, as the investigation is essentially incomplete.

Suppose a horizontal shaft loaded with a central weight W is rotating with angular velocity ω. By reason of an initial "out of balance" centrifugal forces are set up, which create a deflection m. At one time in the course of a revolution the force of gravity will act against the centrifugal forces (Fig. 9), while again it will act in the same direction (Fig. 10). Since the external forces on the shaft are counterbalanced by the elastic forces, it will be seen that there will be a difference between the deflections in the two cases. Let the elastic force be ϵ per unit deflection, and let the deflection in Fig. 9 be m_2, and in Fig. 10 be m_1, then we have :—

$$\frac{W}{g}\omega^2 . m_1 + W = \epsilon m_1$$

$$\frac{W}{g}\omega^2 . m_2 - W = \epsilon m_2.$$

Hence

$$m_1 - m_2 = \frac{2W}{\epsilon - \frac{W}{g}\omega^2} = \frac{2g}{\frac{\epsilon g}{W} - \omega^2}$$

But $\frac{\epsilon g}{W}$ for shaft with single central load $= g/f$, where f is the static deflection.

$$\therefore\ m_1 - m_2 = \frac{2 . g . f}{g - f\omega^2}.$$

From this we see that as ω increases, the difference betwen the deflections will increase until, when $f\omega^2 = g$, we get that :—

$$m_1 - m_2 = \infty .$$

The condition $f\omega^2 = g$ gives the usual critical speed. That, however, is not the point. What we are to consider from the above is the fact that, when the force of gravity is allowed for, there is a variation of the deflection throughout a revolution, which variation may become extremely large as the speed increases. The idea then follows that the effect of gravity is of the nature of a forced vibration. This idea is, however, not very illuminating until it is considered in conjunction with Dr. Chree's theory of a decrease in the natural frequency with increase of speed. There is therefore the possibility that at some particular speed the forced period will coincide with the reduced natural period. Such coincidence could conceivably give rise to a critical speed, if sufficient time were allowed to produce the effect.

The following investigation is an attempt to establish the truth of this idea in a general manner, and in order that the result may be directly applicable to the case of the larger turbine rotor, we consider the case of a simply supported shaft, carrying a load situated off the centre of the span (Fig. 11). The shaft is, of course, considered massless.

The extracts given at the commencement of the investigation are from Dr. Chree's paper* and are included here for the sake of clearness and completeness. It is not usual to consider the "out of balance" of the load, but it is here taken into account as it affects the actual deflection values.

In Fig. 11 :—

O is the centre of rotation.
S is the centre of the shaft.
G is the centre of gravity of the wheel.
O S = deflection of shaft $= m$.
S G = eccentricity of wheel $= e$.
O G = distance of c. of g. of wheel from O $= m+e$.
$\dot{\alpha} = \omega$ = angular velocity.
θ = inclination of wheel to its upright position = slope of the deflected shaft at the wheel.

Also let :—

W = weight of wheel fixed to the shaft in such a position as divides the span l into the two portions a and b.
I = moment of inertia of the shaft section.
E = Young's modulus for the material of the shaft.
I^1 = moment of inertia of wheel about an axis perpendicular to A B and to plane of bending.

The investigation is best introduced by the following extracts from Dr. Chree's paper :—

"The kinetic energy of a body rotating about an axis through its centre of gravity is given by :—

$$T_r = \tfrac{1}{2}(I_1\omega_1^2 + I_2\omega_2^2 + I_3\omega_3^2).$$

* On "The Whirling and Transverse Vibrations of Rotating Shafts," *Philosophical Magazine*, May, 1904.

* Appendix to Dr. Chree's paper.

where I_1, I_2, and I_3 are the principal moments of inertia, and ω_1, ω_2, and ω_3 are the component angular velocities about the three principal axes. Supposing the body one of revolution, and that it rotates with angular velocity ω about a fixed direction, with which its axis of figure makes a small angle θ, then :—

$$\omega_1 = \omega \cos\theta\,; \quad \omega_2 = \omega \sin\theta\,; \quad \omega_3 = \dot{\theta},$$

and

$$T_r = \tfrac{1}{2}\left\{I_1\,\omega^2 - (I_1 - I_2)\,\omega^2 \sin^2\theta + I_2\,\dot{\theta}^2\right\}.$$

If the body be a flat disc $I_1 = 2\,I_2$, and if θ be very small $\sin\theta$ may be replaced by θ, thus :—

$$T_r = \tfrac{1}{2}\,I_1\,\omega^2 + \tfrac{1}{4}\,I_2\,(\dot{\theta}^2 - \omega^2\,\theta^2)\,. \quad . \quad (a)$$

. . . This is, of course, additional to the energy of the mass supposed collected at its centre of gravity."

For the form of the deflected shaft Dr. Chree uses Rayleigh type expressions, thus :—

"For A C (Fig. 11) we measure x from A, and for B C we measure x' from B. At any time, t, suppose shaft deflected at C an amount m from A B in the $x\,y$ plane, and let the tangent to the shaft at C make an angle θ with its undeflected position. Then we must have :—

$$\left.\begin{array}{ll} \text{At } x = 0 & y = d^2y/dx^2 = 0 \\ ,,\ x = a & y = m \text{ and } dy/dx = \theta \\ ,,\ x^1 = 0 & y^1 = d^2y'/dx'^2 = 0 \\ ,,\ x^1 = b & y^1 = m \text{ and } dy'/dx' = -\theta \\ \text{Also } d^4y/dx^4 & = 0 \text{ and } d^4y'/dx'^4 = 0 \end{array}\right\}. \quad (b)$$

And these conditions are easily seen to be satisfied by :—

$$\left.\begin{aligned} y &= (3\,m - a\,\theta)\left(\frac{x}{2\,a}\right) + (a\,\theta - m)\left(\frac{x^3}{2\,a^3}\right) \\ y^1 &= (3\,m + b\,\theta)\left(\frac{x^1}{2\,b}\right) - (b\,\theta + m)\left(\frac{x'^3}{2\,b^3}\right) \end{aligned}\right\} \quad (c)$$

The conditions $d^4y/dx^4 = 0$ and $dy'^4/dx'^4 = 0$ answer to the absence of external forces on the shaft itself—i.e., the shaft is considered massless."

In our case, however, we will express θ in terms of m, as it creates unnecessary complications to consider it as an independent variable. As a matter of fact, this separate consideration of θ is an excessive refinement, which is unjustifiable in view of its extreme smallness in practical cases. From the ordinary static relations for a shaft of this type we could write* :—

$$\theta = -\left(\frac{a-b}{a\,b}\right)m\,. \quad . \quad . \quad . \quad . \quad (d)$$

which will be found to satisfy the conditions (b), and gives us for the deflection expressions :—

$$\left.\begin{aligned} y &= \frac{m}{2\,a\,.\,b}\left\{(a + 2\,b)\,x - \frac{x^3}{a}\right\} \\ y^1 &= \frac{m}{2.a\,.\,b}\left\{(2a+b)x' - \frac{x'^3}{b}\right\} \end{aligned}\right\}. \quad . \quad (e)$$

The Kinetic Energy of the System.—The distance of the centre of gravity of the wheel from the axis of rotation is $(m+e)$.

The total kinetic energy is made up of the energy of the mass supposed concentrated at the centre of gravity, and the energy of rotation expressed by (a) in previous column. The former is given by :—

$$T_t = \tfrac{1}{2}\,\frac{W}{g}\left\{\left[\frac{d}{dt}(m+e)\right]^2 + \dot{a}^2\,(m+e)^2\right\}$$

$$= \tfrac{1}{2}\,\frac{W}{g}\,(\dot{m}^2 + \dot{a}^2\,(m+e)^2).$$

Hence by combination with (a) we obtain for the total kinetic energy :—

$$T = T_r + T_t = \tfrac{1}{2}\,I_1\,\omega^2 + \tfrac{1}{2}\,I_2\,(\dot{\theta}^2 - \omega^2\,\theta^2) + \tfrac{1}{2}\,\frac{W}{g}\left\{\dot{m}^2 + \dot{a}^2\,(m+e)^2\right\}$$

But substituting for θ from (d), and writing I′ in place of I_2, we get :—

$$T = \tfrac{1}{2}\,I_1\,.\,\omega^2 + \tfrac{1}{2}\left(\frac{a-b}{a\,b}\right)^2.\,I'(\dot{m}^2 - \omega^2\,m^2) + \tfrac{1}{2}\,\frac{W}{g}\left\{\dot{m}^2 + \omega^2\,(m+e)^2\right\} \quad . \quad . \quad (f)$$

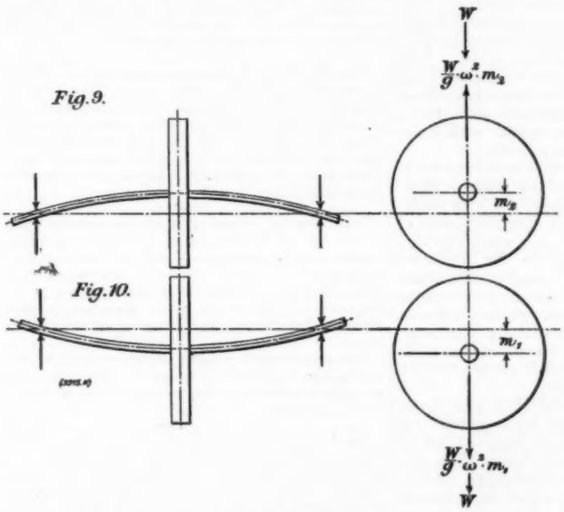


Fig. 9.

Fig. 10.

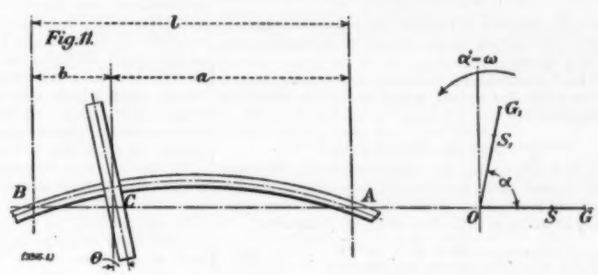


Fig. 11.

The Total Potential Energy of the System.—The total potential energy is made up of the strain energy of the bent shaft, and the energy of position of the mass.

On the ordinary theory of bending the strain energy of a deflected beam is given by :—

$$\frac{1}{2\,E\,I}\int M^2\,.\,dx = \tfrac{1}{2}\,.\,E\,I\int\left(\frac{d^2y}{dx^2}\right)dx.$$

Hence the strain energy of the shaft is :—

$$S = \tfrac{1}{2}\,.\,E\,I\left\{\int_0^a\left(\frac{d^2y}{dx^2}\right)dx + \int_0^b\left(\frac{d^2y'}{dx'^2}\right)dx'\right\}.$$

So that from (e) we obtain :—

$$S = \tfrac{1}{2}\,.\,E\,.\,I\,.\,\frac{m^2}{a^2\,b^2}\left\{\left[\frac{9\,x^5}{5\,a^2}\right]_0^a + \left[\frac{9\,x'^5}{5\,b^2}\right]_0^b\right\}$$

$$\therefore S = \frac{3\,.\,E\,I\,m^2\,(a+b)}{2\,a^2\,b^2} \quad . \quad . \quad (g)$$

Considering the horizontal through O as the datum for gravity, we can write for the energy of position of the mass :—

$$P = W\,(m+e)\sin\alpha \quad . \quad . \quad . \quad (h)$$

Hence for the total potential energy of the system we have :—

$$V = S + P = \frac{3\,.\,E\,.\,I\,.\,m^2\,(a+b)}{2\,a^2\,b^2} + W\,(m+e)\sin\alpha \quad . \quad . \quad . \quad (k)$$

Having obtained these expressions for the kinetic and potential energy values, we can now apply Lagrange's equation, which has the form :—

$$\frac{d}{dt}\left(\frac{\delta\,T}{\delta\,\dot{m}}\right) - \frac{\delta\,T}{\delta\,m} + \frac{\delta\,V}{\delta\,m} = 0 \quad . \quad (l)$$

Differentiating (f) and (k) thus :—

$$\left.\begin{aligned} \frac{\delta\,T}{\delta\,\dot{m}} &= \left\{\frac{W}{g} + \left(\frac{a-b}{a\,b}\right)^2 I'\right\}\dot{m} \\ \therefore\ \frac{d}{dt}\left(\frac{\delta\,T}{\delta\,\dot{m}}\right) &= \left\{\frac{W}{g} + \left(\frac{a-b}{a\,b}\right)^2 I'\right\}\ddot{m} \\ \frac{\delta\,T}{\delta\,m} &= \frac{W}{g}\,.\,\omega^2\,(m+e) - \left(\frac{a-b}{a\,b}\right)^2 I'\,.\,\omega^2\,.\,m \\ \frac{\delta\,V}{\delta\,m} &= \frac{3\,E\,I\,(a+b)}{a^2\,b^2}\,.\,m + W\,.\,\sin\alpha\,. \end{aligned}\right\} \quad (o)$$

Substituting from (o) in (l) we get :—

$$\left\{\frac{W}{g} + \left(\frac{a-b}{a\,b}\right)^2 I'\right\}\ddot{m} - \frac{W}{g}\,.\,\omega^2\,(m+e) + \left(\frac{a-b}{a\,b}\right)^2 I'\,.\,\omega^2\,m + \frac{3EI(a+b)}{a^2\,b^2}\,m + W\,.\sin\omega\,t = 0,$$

i.e.,

$$\ddot{m} + m\left[\frac{3\,g\,.\,E.\,I\,.\,l - \omega^2\left\{W\,a^2\,b^2 - g\,I'\,(a-b)^2\right\}}{W\,a^2\,b^2 + g\,I'\,(a-b)^2}\right] = \frac{W\,a^2\,b^2}{W\,a^2\,b^2 - g\,I'\,(a-b)^2}\,(\omega^2\,e - g\sin\omega\,t) \quad (p)$$

For simplicity let us write :—

$$A = \frac{3\,g\,.\,E.\,I.\,l}{W\,a^2\,b^2 + g\,I'\,(a-b)^2};$$

$$B = \frac{W\,a^2\,b^2 - g\,I'\,(a-b)^2}{W\,a^2\,b^2 + g\,I'\,(a-b)^2};$$

$$C = \frac{W\,a^2\,b^2}{W\,a^2\,b^2 + g\,I'\,(a-b)^2}$$

Then (p) becomes :—

$$\ddot{m} + (A - B\,\omega^2)\,m = C\,(\omega^2\,.\,e - g\,.\,\sin\omega\,t) \quad (q)$$

This differential equation is of a well-known type. The solution is as follows :—

For the complementary function :—

$$m = F\cos\sqrt{(A - B\,\omega^2)}\,.\,t + E\sin\sqrt{(A - B\,\omega^2)}\,.\,t.$$

And for the particular integral :—

$$m = \frac{C}{D^2 + (A - B\,\omega^2)}\left\{\omega^2\,e - g\sin\omega\,t\right\}$$

(where D denotes $\frac{d}{dt}$).

$$\therefore m = C\left\{\frac{\omega^2}{A - B\,\omega^2}\,.\,e + \frac{g}{(B+1)\,\omega^2 - A}\sin\omega\,t\right\}.$$

Hence we have :—

$$m = F\cos\sqrt{A - B\,\omega^2}\,.\,t + E\sin\sqrt{A - B\,\omega^2}\,.\,t + C\left\{\frac{\omega^2}{A - B\,\omega^2}\,.\,e + \frac{g}{(B+1)\,\omega^2 - A}\,.\,\sin\omega\,t\right\} \quad (r)$$

Equation (q) is the differential equation of the motion of a body under the action of a periodic disturbing force. The natural frequency is given by :—

$$\frac{\sqrt{A - B\,\omega^2}}{2\,\pi}$$

And the forced frequency is given by :—

$$\frac{\omega}{2\,\pi}.$$

Now the last term in (r)—viz. :—

$$C\left\{\frac{\omega^2}{A - B\,\omega^2}\,.\,e + \frac{g}{(B+1)\,\omega^2 - A}\sin\,.\,\omega\,t\right\}$$

becomes infinite for either of the two conditions :—

$$A - B\,\omega^2 = 0, \text{ or } (B+1)\,\omega^2 - A = 0.$$

From the expressions given above for the natural and forced frequencies, it will be easily seen that these two conditions answer respectively to natural frequency zero, and to coincidence between the forced and natural periods. The former gives the usual critical speed, and is merely the symbolical representation of Dr. Chree's theory. The latter constitutes the new point which we set out to establish.

We have therefore arrived at the actual value of a new critical speed, which, so far as the mathematics can show, would seem to be as important as the other. It is interesting to note that, by this investigation, in which we have included two factors usually neglected in the mathematical treatment of this subject (viz., the action of gravity on the mass and its eccentricity), we arrive at a result which gives the actual values of two different critical speeds, and points out their physical meaning.

For the value of the new critical speed we have :

* It was by making this simplification in Dr. Chree's general analysis that the equation used in the calculation of the critical speed of the 250-kw. turbine was obtained (see Method III., equation (3)). It was subsequently found that Dr. Chree gives a similar equation in another part of his paper, obtained by means of a corresponding simplification.

$$(B + 1)\omega^2 - A = 0,$$

i.e.,

$$\frac{2 W a^2 b^2 \omega^2 - 3g \cdot E \cdot I \cdot l}{W a^2 b^2 + g I'(a-b)} = 0$$

$$\therefore \omega_k^2 = \frac{3g \cdot EI \cdot l}{2 W a^2 b^2} \quad . \quad . \quad . \quad (s)$$

The value of ω_k given by (*s*) is clearly much below the usual theoretical value (ω_c). It also seems to be independent of I'.

The usual critical speed is given by :—

$$A - B\omega^2 = 0.$$

From which we get :—

$$\omega_c^2 = \frac{3g \cdot E \cdot I \cdot l}{W a^2 b^2 - g I'(a-b)^2}$$

This equation has already been used in the calculation of the critical speed, equation (3). This shows the effect of I' in raising the whirling speed above what it would be if I' were neglected.

Again, by putting $\omega = 0$ in (*q*) we obtain the natural frequency of the loaded shaft (when not rotating) as $\sqrt{A}$, *i.e.* :—

$$p^2 = \frac{3g \cdot EI \cdot l}{W a^2 b^2 + g I'(a-b)^2}$$

Here we see how I' reduces the natural frequency in contradistinction to its effect in increasing the whirling speed.

We now proceed to consider our result in connection with the actual turbines which we have investigated.

APPLICATION TO THE ACTUAL CASES.

250-*Kw. Turbine.*—In order to obtain the new critical speed value for this turbine rotor we use the values arrived at by Method I., altering equation (1) to bring it into line with (*s*), thus :—

$$N_k = \frac{30}{\pi}\sqrt{\frac{g \Sigma (W y)}{2 \Sigma (W y^2)}} \quad . \quad . \quad (I')$$

Taking the totals from the table on page 151 *ante*, and substituting in (I') we get :—

$$N_k = \frac{30}{\pi}\sqrt{\frac{32.2 \times 12 \times 3239 \times 10^{-3}}{2 \times 10{,}321 \times 10^{-6}}}$$

$$= 2352 \text{ revolutions per minute.}$$

It will be remembered that the original calculation resulted in the value $N_c = 3338$ revolutions per minute, while the actual value is 2450 revolutions per minute. Obviously, therefore, our "new" value is in much closer agreement with the actual than is that calculated by the usual theory, the error being :—

$$100\left(\frac{2450 - 2352}{2450}\right) = +4 \text{ per cent.}$$

This very close agreement provides us with the best evidence as to the truth of our theoretical result, and would seem to show that it merits the consideration of designers. It is to be noticed, moreover, that this 4 per cent. error is in the correct direction, as we have elsewhere pointed out that a theoretical calculation should give a low value, owing to the neglect of certain minor stiffening effects.

3-*Horse Power Turbine.*—From considerations which have been fully discussed, it would seem best to allow that the observed value of 8640 revolutions per minute agreed with the usual theory. Although our investigation is not directly applicable to this turbine, it is clearly of a very general nature, and, knowing the ordinary critical speed, we could arrive at a fairly approximate value for the "new" critical speed thus :—

$$N_k = \frac{1}{\sqrt{2}} N_c$$

$$= \frac{1}{\sqrt{2}} \ 8640 = 6110 \text{ revs. per min.}$$

Now it will be remembered that, from the actual observations made, whirling seemed to commence at about 6600 revolutions per minute, and continued to 8640 revolutions per minute. The obvious explanation in this case is, therefore, that whirling was maintained throughout the range of speed between the two values given by the theory, the discrepancy between the calculated 6110 revolutions per minute and the actual 6600 revolutions per minute being due mostly to the difficulty of making accurate observations with the rough method employed (see page 197 *ante*). The comparative indefiniteness of the occurrence at the low value would, no doubt, be due largely to the rapidity with which the speed increased. This would prevent a full development of the "whirl." At the higher value, the whirling tendency would be aggravated by the instability previously set up. It is also probable that (despite the mathematics) the two critical speeds are not quite of equal importance, more especially when it is merely a question of passing through them.

In the case of the larger turbine, where the speed increased much more slowly, the whirling at the low value was quite definite; but we are unable to make a comparison with the occurrence at the higher value, as that was never attained, the emergency governor coming into action some time before even the theoretical value was reached.

It is to be noted that in neither case could it be said that the noise and vibration died out between the critical values. With the larger turbine there was a certain abatement beyond 2600 revolutions per minute, but there was no complete cessation. If we could have carried the speed higher, we should probably have found that the noise would increase again, to cease finally at about 3500 revolutions per minute. With the small turbine there was not the slightest indication of a diminution in the noise between its commencement and finish, observation showing a very rapid growth in intensity. These facts would seem to show that there was a certain tendency to whirl at all speeds between the two critical values. This would also serve to account for the somewhat large range over which whirling has frequently been observed to occur. It would therefore seem to be undesirable to have a running speed within the range between the two critical speeds.

It would seem improbable that whirling could occur to any great extent at the low value in those cases where the loads on the shaft are very small. This would help to account for the slightness of the whirling effect noticed with our small turbine, and would also serve to explain the apparent absence of this lower critical speed in Professor Dunkerley's experiments. It is to be remembered in connection with these that while Professor Dunkerley used a shaft of practically the same diameter as that of our De Laval turbine, his wheels were only about one-eighth to one-twelfth the weight of the De Laval wheel.

It is also interesting to note that this lower critical speed might account to some extent for whirling troubles that have been encountered in actual practice at speeds much lower than the critical speed estimated by the designer. In this connection it is perhaps fortunate that designers have been in the habit of allowing themselves a margin of about 30 per cent. on the estimated critical value. Since estimates of critical speeds—in those cases in which the conditions are fairly definite—are invariably low, the real margin allowed is probably nearer 35 to 40 per cent., which is more than sufficient to clear completely the lower value.

From the foregoing discussion it will be seen that the theoretical result which we have endeavoured to establish allows us to give a fairly satisfactory explanation of the various difficulties discovered by our investigations with these two turbines. Undoubtedly, the important case is that of the 250-kw. turbine, which provides us with a perfectly definite result; but at the same time the fact that the phenomena observed in connection with the 3-horse-power turbine can be explained along the same lines is additional evidence, which is not to be despised.

SUMMARY.

The following brief summary of the important points may be interesting :—

(*a*) That there is both experimental and theoretical evidence of the existence of a critical speed for loaded horizontal shafts which is considerably below that given by the usual theory.

(*b*) That this "new" critical speed is due in the first instance to the direct effect of gravity, which has been hitherto neglected in the theory.

(*c*) That the lower critical speed seems to be less important than the higher, when it is merely a question of running through in the process of speeding up. And also of little importance when the loads on the shafts are very light. In those cases in which it is clearly shown, it is probably due to inaccurate balancing.

(*d*) That in general there will be an undesirable instability at all speeds between the two critical values, and that it would be best to keep the normal running speed outside this range.

In conclusion, I beg to express my thanks to Professor A. L. Mellanby, D.Sc., for permission to carry out this investigation, and to make the necessary observations, as this subject was not originally included in the scheme of research work. I am also very grateful to Professor J. Miller, D.Sc., M.A., and to Professor J. Muir, D.Sc., M.A., for their kindness in considering certain points which were submitted to them, with results advantageous alike to the paper and to the author.

(*To be continued.*)

INDUSTRIAL NOTES.

OWING to the impending departure of Sir George Barnes for India, to take up the position of Commercial Member of the Viceroy's Council, Sir Hubert Llewellyn Smith is about to resume active duty as Permanent Secretary to the Board of Trade. He will not relinquish his position as General Secretary to the Ministry of Munitions, which he has occupied since its establishment; but Mr. Lloyd George has appointed Mr. Edmund Bampfylde Phipps (a Principal Assistant Secretary of the Board of Education, whose services have been temporarily placed at the disposal of the Ministry by the Board) to be an additional General Secretary. The President of the Board of Trade has appointed Mr. W. F. Marwood, C.B., to be Second Secretary to the Board of Trade.

The Minister of Munitions announces that he has made an Order, under Section 4 of the Munitions of War Act, 1915, delaring 218 additional establishments to be controlled establishments under the Act as from March 6, 1916. A total of 3052 establishments have now been declared as controlled under the Act from the date of the first Order, July 12, 1915, to March 3, 1916, inclusive.

The Central News Agency announces that the secretaries of British trade unions have received a communication from the Board of Trade stating that repayments of unemployment benefits which they have hitherto received from the Treasury in relief of their financial liabilities to their members under the National Insurance Act must cease at the end of May next.

The letter points out the urgent necessity for economising, and refers to the fact that there is practically no unemployment at the present time among trade-union members.

Sir George Croydon Marks, M.P., the Government Special Commissioner for the Dilution of Labour, addressed a meeting last Friday at the works of Messrs. C. A. Parsons and Co., Heaton, in the course of which he stated that the object of his visit was to enlist the co-operation of the men and to get their sympathy in what was necessary to be done in order to increase the output of the work they were now engaged upon. The primary intention of the Government in pressing labour dilution had been recognised by all the trade-union associations as necessary to secure increased output of plant, machinery, and munitions needed in the war, and was not concerned so much with economy. At present there was a struggle facing the nation that the engineers were called upon to meet, and he was asking the skilled engineers of Heaton to use their fullest skill to the best advantage by allowing others, having lesser skill, to do some of the work which the engineers were doing, and which might readily be learned by unskilled persons. This proposal was not made for the benefit of the firm, or to increase the latter's dividends, or to promote the interests of the shareholders, but to promote the safety of the realm. Unless what they proposed were done, they would be confronted with a difficulty that would get worse every day. He appealed to the men to believe, in this time of trouble, that there was no division between trade unions and employers. All were working and making sacrifices, and it was perfectly safe to say that no public man could address any gathering from the remotest village to the largest city without knowing that in his audience were men and women mourning for those they had lost in the war. Although he asked the men at the Heaton works to permit dilution to be effected by the introduction of unskilled persons, men and women, to do some of the work previously done by skilled workmen, they were not to undertake it at prices that would mean greater money for the employers and less wages for the workers. A rule was laid down that for the same output there must be the same price paid. The period of probation, which was said to be about two months, should be sufficient for the unskilled person to become sufficiently familiar with the work to earn the same money as the skilled worker did, and if the necessary skill were acquired in less than that time, full money would be paid at once.

Sir George added that a record-book would be kept by the firm in which all stages and classes of dilution would be recorded, with the names of the persons

transferred, and the book would be open to the shop stewards, while at the end of the war a copy would be available for the societies concerned. The work comprised in the dilution scheme included blading, ordinary fitting, and machine work. While it was impossible to make a competent mechanic in two months, it was possible to make a non-skilled person proficient in those particular kinds of work in that time, and thus there would be a material increase in the output by the dilution. Whilst some work might not, to the knowledge of the men, be Government work, it was national work needed for the maintenance of the national life.

The scheme for dilution is to be put immediately into operation at the Heaton works.

An appeal to employers has been issued through the combined action of the Home Office and the Ministry of Munitions. The appeal is signed by Mr. Herbert Samuel, Home Secretary, and Mr. Walter Runciman, President of the Board of Trade. It calls the attention of employers to the urgent necessity of concerted action for the purpose of making good the loss of labour caused by the withdrawal of the men for the Forces, and asks every employer who finds his business threatened with diminished productivity through the loss of men, not to accept such a diminution as an inevitable consequence of the war, but to make every possible effort to maintain his production by using women, whether in direct substitution to the men or by some other sub-division or rearrangement of his work. Every employer, therefore, is urged :—1. To review the organisation of his works in order to ascertain how it is possible, by rearrangement of work and other measures, profitably to employ, as temporary substitutes, as large a number of women workers as possible. 2. To send to the local Labour Exchange at once—and from time to time as the situation develops—particulars of his requirements for women labour, with the fullest possible details as to the classes of work and the qualifications required.

For the work of canvassing and drawing in the reserves of women, it is proposed to invite local assistance of persons qualified by their experience of commercial enterprise, industrial conditions, and social work, and steps are already being taken to make arrangements for this.

The introduction of women into a factory or a department where previously men have been employed may cause the employer some difficulties in the matter of arranging for conditions of work suitable to women, or complying with the requirements of the Factory Acts, but in many industries these have already been overcome as a result of discussion between the employers or their associations and the officials of the Home Office, and every effort will be made by the Home Office and the Factory Inspectors to advise and assist employers in meeting such difficulties.

In connection with the appeal, the Board of Trade, after consultation with the Home Office, have appointed an Advisory Committee, with the following terms of reference :—

1. To advise the Board of Trade and Home Office on questions arising from time to time out of the measures required to be taken by these Departments to give practical effect to the policy of His Majesty's Government for extending the employment of women in industrial occupations, so as to enable essential industries to be maintained in spite of the depletion of their supply of male labour by recruiting for war purposes ; and

(2) To watch and report from time to time on the progress made in different localities and industries in the extension of the employment of women.

The *Sheffield Daily Telegraph* states that an important award on the application of the Sheffield allied engineering trades for an advance of wages of 10s. per week on time rates, 25 per cent. on piece rates, and 5s. for youths, was made known on Tuesday last.

The Committee on Production, who formed the Court of Arbitration, have refused the triple application.

The official award is as follows :—

"The following finding (which is made by Sir George Askwith, Sir George Gibb, and Sir David Harrel) is in respect of an application for an advance of wages made to the Sheffield and District Engineering Trades Employers' Association by the Amalgamated Society of Engineers, United Machine-Workers' Association, the Toolmakers' Association, the Electrical Trades Union, the Steam-Engine Makers' Society, the Smiths' and Strikers' Association, Coremakers' Society, the Operative Painters' Society, the Wood-Cutting Machinists, Winding and General Engineers' Society, the Iron and Steel Pressers' Society, and the United Pattern-Makers' Society.

"The application, which was for an advance of 10s. per week on time rates and 25 per cent. on piece rates (and an advance of 5s. per week to youths between sixteen and twenty-one years of age) was discussed between the parties at a local conference on December 8, 1915, and at a central conference on January 10, 1916, but no settlement was arrived at, and it was agreed to refer the matter to the Committee on Production for a decision. Representatives of the parties were accordingly heard on February 23.

"At the hearing it appeared that the claim was based to some extent upon the fact that the semi-skilled and unskilled workers engaged in the production of shells in Sheffield are at present making very high earnings—much in excess of the earnings of the skilled men concerned in the claim now under consideration.

"The circumstances which have led to these high earnings are abnormal, and while appreciating the point of view of the skilled men, the Committee feel that the claim which has been put forward by the unions on their behalf is not a proper means of remedying the position.

"In March, 1915, the skilled men received an advance of 4s. per week on time rates, and 10 per cent. on piece rates, and the Committee's finding is that the claim for the further advance of wages has not been established."

The *London Gazette* publishes an announcement from the Ministry of Munitions to the effect that certain members of the Territorial Force who are not liable for foreign service have, under authority given by the War Office, been released from military duty for the purpose of working at their trades or in connection with the production of munitions of war, and are so employed.

Accordingly, the Minister of Munitions, after consultation with the Army Council, certifies that the work upon which these members of the Territorial Force so released are employed is work of national importance, and that as a class they are exempted from the provisions of the Military Service Act until the War Office recalls them to military duty or the Minister of Munitions informs the War Office that he has no further use for their services on munition work, whichever first happens.

The state of affairs in German export textile business is by no means satisfactory, says the *Textile Mercury*. The hopes entertained by textile firms that, in spite of the war, business with the neutral markets would not only continue, but even improve, have not been fulfilled. In addition, trade with Austria, Hungary, Bulgaria, and Turkey is, if anything, worse than usual. The Polish textile industry, which bought freely of fabrics and yarns before the war, is now buying next to nothing ; furthermore, the large credits outstanding in Lodz, Bialystock, and other trade centres seem very likely to remain so indefinitely. The entire loss of Russian trade has been a very serious blow to German textile circles. Business with South America has dwindled almost to nothing, due to lack of freight facilities, high maritime insurance premiums, and the low value of German currency. Many houses have closed either wholly or partly, while those depending upon expert English assistants have had to abandon certain branches of their business altogether.

The same journal gives publicity to a report issued by H.M. Consul at Lyons to the effect that the German occupation of Roubaix and other industrial centres in the North of France has been the means of bringing an unlooked-for degree of prosperity to the Lyons district, which is now busily engaged in manufacturing woollen goods on looms set free by the falling-off in the demand for muslins and other light fabrics of silk. It is estimated that no fewer than 8000 to 10,000 of these looms are at present turning out light woollen dress fabrics, of which at least 6000 are working on account of the manufacturers at Roubaix and elsewhere, while the remainder are working under the immediate orders of Lyons silk manufacturers acting as intermediaries for manufacturers in the north. These goods are not treated in Lyons, but are sent in the grey or gum state to Paris, where they are dyed and finished at a large establishment well known for this work before the war.

It is confidently anticipated that this industry, having thus found itself transplanted to Lyons by the fortune of war, will become established there on a permanent footing, and will add considerably to the industrial importance of the district.

The *Anglo-Norwegian Trade Journal* refers to the law on labour disputes in Norway, which came into force on January 1, and to which we called attention on page 101 *ante*. The law creates, for the first time in Norway, machinery for the settlement of labour disputes by the State. One noteworthy feature of the new measure is that it applies the principle of compulsory investigation and delay before stoppage of work takes place, in which respect it resembles the Canadian Industrial Disputes Act of 1907. Other noteworthy features are the compulsory registration of trade unions and employers' associations, and the recognition and regulation of collective agreements. With regard to the prevention and settlement of labour disputes, two methods of procedure are established. Questions arising out of existing collective agreements must be brought before a specially constituted Labour Court, while those originating in other matters affecting labour are to be submitted to Conciliation Boards to be set up throughout the country. The Labour Court is to consist of a president and four other members, all of whom are to be appointed by the Crown. The president must be qualified to act as a judge in the Supreme Court. Under no circumstances may a strike or lock-out be resorted to for the purpose of determining the validity, the interpretation, or the continuation of a collective agreement, or with the object of enforcing demands based upon such an agreement. All controversies of this kind must be referred to the Labour Court for decision, unless the parties agree to settle their differences by private arbitration. The procedure for dealing with disputes which do not arise out of collective agreements is to be controlled by a permanent chief conciliator, and the whole country is to be divided into conciliation areas, over each of which a district conciliator is to be appointed. The chief and the district conciliators are to be nominated by the Crown, and are to hold office for a term of three years. Each district conciliator will act as the chairman of a Conciliation Board, consisting of himself and two persons to be selected by him from panels of candidates. These panels are to be nominated for each district (in numbers to be fixed subsequently) by registered associations of employers and workpeople. Proceedings both before the Labour Court and the Conciliation Boards are free of cost to the parties. Infractions of the provisions of the law are punishable by fines ranging from 5s. 7d. to 138*l*.

ROYAL SOCIETY OF ARTS—PETER LE NEVE FOSTER PRIZE.—The prize of 10*l*. and a silver medal, offered under the Peter Le Neve Foster Trust, by the Royal Society of Arts, for an essay on "Zinc, its Production and Industrial Applications," has been awarded to Mr. J. C. Moulden, A.R.S.M., M. Inst. M.M., of Seaton Carew, co. Durham. Honourable mention has also been awarded to Mr. Ernest Alfred Smith, A.R.S.M., M. Inst. M.M., Deputy Assay Master of the Sheffield Assay Office, for his essay. The adjudicators, on whose recommendation the award was made, reported that the two essays above mentioned were distinctly superior to the others, several of which, nevertheless, were of interest and value. An essay by Mr. Ramji Das Vaishya, of Gwalior, Central India, contained a good deal of information with regard to the production and utilisation of the metal in the East Indies. The prize essay will be read in abstract at one of the meetings of the Society after Easter.

GERMAN TRADE WITH CHINA.—As an indication of German methods in China, the *London and China Telegraph* quotes the following passage from a paper read by the Hon. Joseph E. Davies, chairman of the Federal Trade Commission, before the National Foreign Trade Council at New Orleans :—"Much of the Oriental business of Germany is alleged to have been acquired through so-called 'rings,' which include representatives of every kind of industry whose goods or services might be required. The markets are scientifically studied and assiduously cultivated. One of these rings consists of forty-eight different manufacturers. Its organisation with the local bank and home bank connections is complete. It has within its organisation facilities for selling to a Chinaman a file, or for planning, financing, and completing the industrial development of an entire province, opening harbours, building railways and telegraph lines, sinking mines, erecting factories, installing light and power plants, and even to clothing the people and marketing their products." British traders, adds the *Telegraph*, would do well to take note of the kind of thing they are likely to have to face in meeting German competition in China.

THE LATE MR. ROBERT ARTHUR DAWBARN.—We regret to have to record the death, after a short illness, of Mr. Robert Arthur Dawbarn. Mr. Dawbarn was born in November, 1860. He was educated at Tettenhall College, where he spent five years, from 1873 to 1877, his scientific training having been acquired at Anderson's College, now the West of Scotland Technical College, Glasgow, where he followed a two years' course, from 1878 to 1880. During that same period, down to 1880, Mr. Dawbarn served his pupilage with Messrs. Neilson and Co.—later Neilson, Reid and Co.—being engaged in the various departments from the pattern-shop to the erecting-shop, and about one year in the drawing-office. He was appointed in 1881 assistant engineer to the British Electric Light Company, since which date he had been continuously engaged in electrical engineering. He remained three years with that company ; he then entered Messrs. Siemens Brothers and Co.'s works, where he also remained three years. He afterwards entered the works of the Brush Electrical Engineering Company, Limited, where he remained thirteen years, first as chief assistant-engineer under Mr. J. S. Raworth, being appointed superintending engineer in 1897. Mr. Dawbarn resigned his position with the Brush Company in 1900 to take up consulting practice in partnership with Mr. W. M. Mordey, with whom he carried out electrical and general engineering work, in connection with which Mr. Dawbarn was employed on contracts for abroad, in South America, South Africa, and Portuguese East Africa. Mr. Dawbarn was a member of the Institution of Civil Engineers and of the Institution of Electrical Engineers.

30-TON TRAVERSER AT MOOR-STREET GOODS STATION, BIRMINGHAM.

MOST of the sidings and platforms at the Moor-street goods station of the Great Western Railway at Birmingham are on a lower floor, and to these wagons arriving on the upper level have to be lowered by lifts, and thence distributed to their destined platform by means of a traverser. A plan of this floor for one-half of the goods shed is reproduced in Fig. 1, annexed. The railway tracks shown on the right-hand side of this figure are 30 ft. to 40 ft. above the tracks in the shed below. It will be seen that there are two lifts, one rated at 30 tons, and another (in the right-hand upper corner of the plan) at 20 tons. The wagons when lowered are delivered to a 30-ton traverser which runs on the four-rail tracks shown, across the heads of the loading tracks. A large proportion of the goods handled here are of a perishable nature, such as fruit and vegetables, so that it was highly important that the traffic should be handled as expeditiously as possible.

It was decided that this traverser—marked Traverser No. 1 on the plan—should be driven electrically. The traverser has, it will be seen, to serve any one of eight sidings, and match its rails with theirs. Fearing that with any form of three-phase motor-drive much time would be lost in the above-named operation, Mr. Roger T. Smith, the electrical engineer to the Great Western Railway Company, decided to adopt the Compayne (Hele-Shaw) hydraulic transmission gear for communicating the drive from the motor to the wheels. This arrangement has proved most successful, and the ease with which the traverser can be accelerated, or retarded, stopped, or reversed is very remarkable. We may note in passing that a second 30-ton traverser is to be erected in the other half of the shed shown in the plan, on the opposite side of Park-street, but as this has to serve three sidings only, it has not been thought necessary to adopt the Hele-Shaw gear in this case. On the completion of this second traverser it will be possible to make a very interesting comparison between the working of the two types.

Traverser No. 1 was constructed to the drawings and specification of Mr. Roger T. Smith, by Messrs. Stothert and Pitt, Limited, of Bath, and a general view of it at the makers' works is given in Fig. 4, Plate XXIII., whilst an elevation and plan respectively are reproduced in Figs. 2 and 3, Plate XXII.

The traverser comprises as its main components a central electrically-driven locomotive, and two detachable traversing-carriages, each suitable for carrying a loaded wagon weighing 30 tons. The locomotive carriage is built up of rolled-steel sections, and runs on four lines of rails on eight cast-steel wheels, mounted on two axles. The traversing motion is, as already

30-TON TRAVERSER AT MOOR-STREET STATION.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, BATH.

Fig. 1.

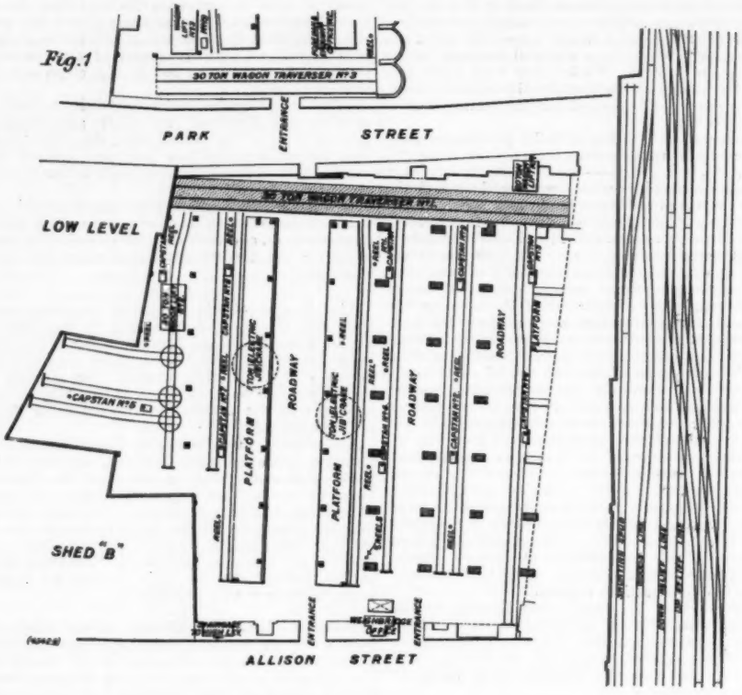
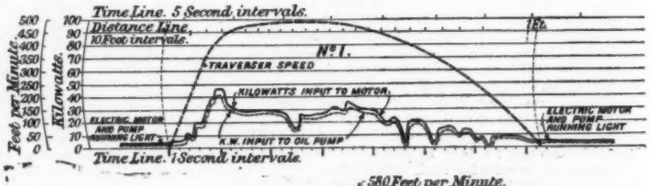
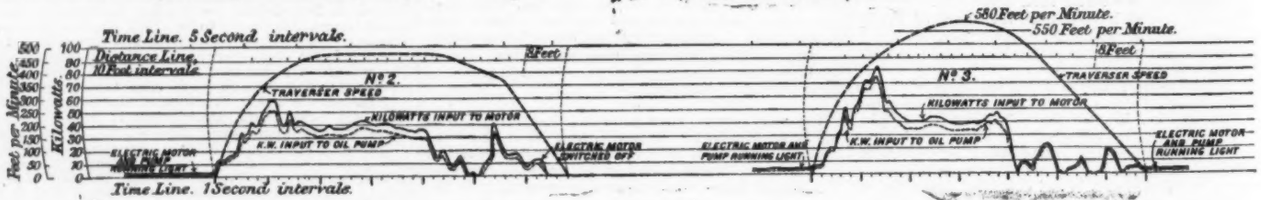
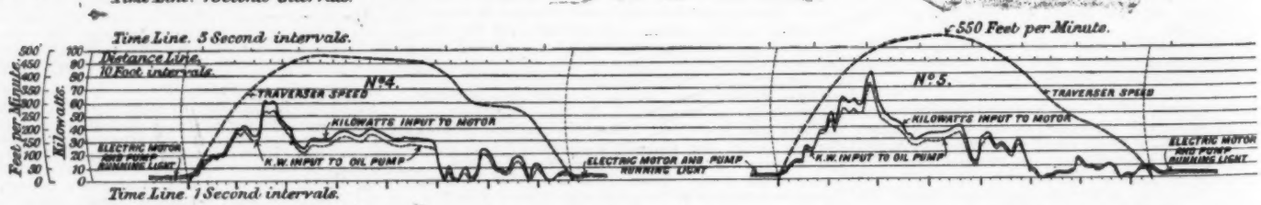
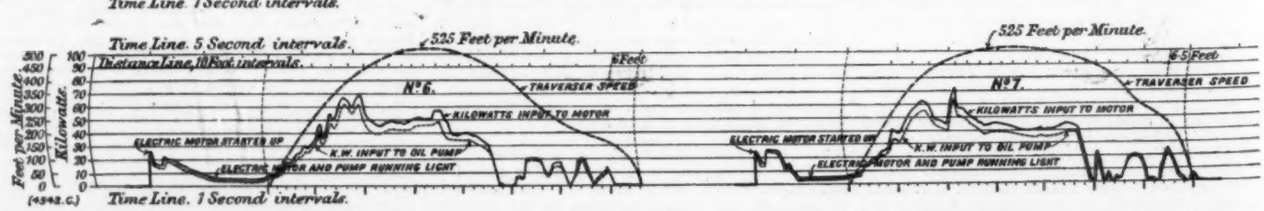


Fig. 5.




Time Line. 5 Second intervals.
Distance Line. 10 Feet intervals.
Nº 2.
580 Feet per Minute.
550 Feet per Minute.
Nº 3.
TRAVERSER SPEED
KILOWATTS INPUT TO MOTOR
K.W. INPUT TO OIL PUMP
ELECTRIC MOTOR AND PUMP RUNNING LIGHT
Time Line. 1 Second intervals.


Time Line. 5 Second intervals.
Distance Line. 10 Feet intervals.
Nº 4.
550 Feet per Minute.
Nº 5.
TRAVERSER SPEED
KILOWATTS INPUT TO MOTOR
K.W. INPUT TO OIL PUMP
ELECTRIC MOTOR AND PUMP RUNNING LIGHT
Time Line. 1 Second intervals.


Time Line. 5 Second intervals.
Distance Line. 10 Feet intervals.
525 Feet per Minute.
Nº 6.
Nº 7.
TRAVERSER SPEED
KILOWATTS INPUT TO MOTOR
K.W. INPUT TO OIL PUMP
ELECTRIC MOTOR AND PUMP RUNNING LIGHT
Time Line. 1 Second intervals.

(4342.C.)

mentioned, transmitted from the electric motor to the axles by means of the Compayne (Hele-Shaw) variable-speed oil transmission gear and Hans Renold pitch chain. The Hele-Shaw transmission gear consists of an oil-pump driven from the electric motor, and three oil-motors driven from the oil-pump. Two of these oil-motors, shown in Fig. 3, are required for traversing, and one (shown in Fig. 2) for operating the capstan-head, by means of which the wagons are hauled on or off the traversing-carriages. The oil-motors are governed by regulating the pump capacity; change-over valves, non-return valves, safety-valves, and pressure-gauges being also provided.

We may remind our readers that the Hele-Shaw gear is based upon the use of a variable-stroke pump operating with oil. The variable stroke enables the volume of oil delivered to be varied, and consequently, whilst the electric motor runs at constant speed, any required pressure can be obtained in the working fluid by giving a suitable stroke; and as the torque of the oil-motor is proportional to the pressure, a very great starting effort is obtained without necessitating a rush of current through the electric motor.

It is obvious that in dealing with the great masses which have to be set in motion, as in the present case, it is of the greatest advantage to be able to obtain a high torque by merely actuating a lever controlling the pump stroke, and hence to set in motion the traverser, even when fully loaded, with the greatest ease, and

HELE-SHAW GEAR FOR 30-TON TRAVERSER AT MOOR-STREET GOODS STATION.

CONSTRUCTED BY MESSRS. COMPAYNE, LIMITED, ENGINEERS, LONDON.

Fig. 6.

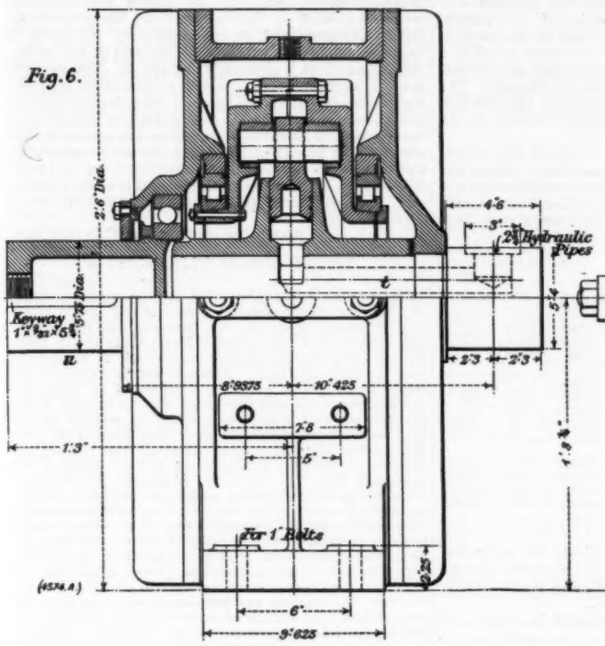


Fig. 7.

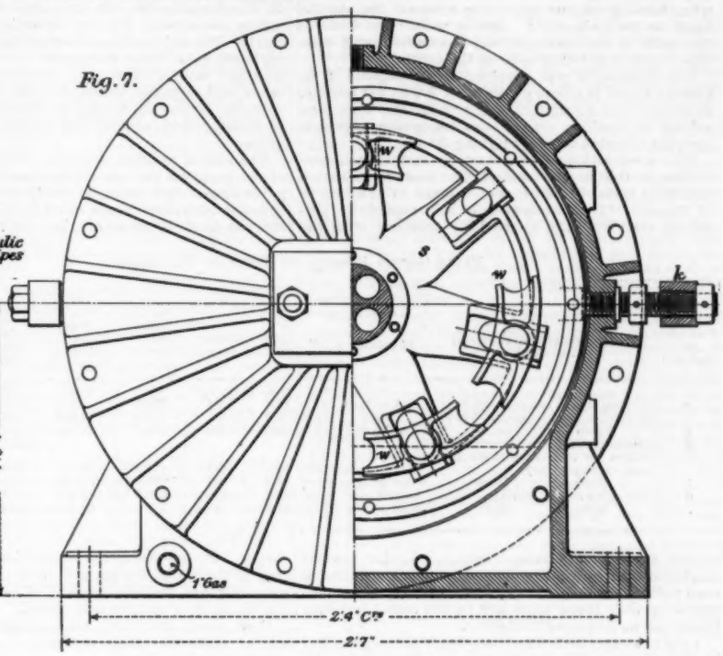


Fig. 8.

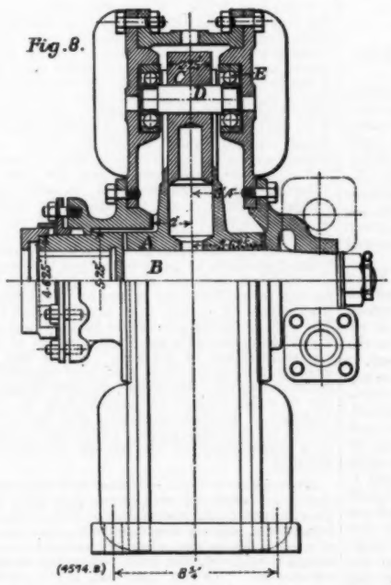


Fig. 9.

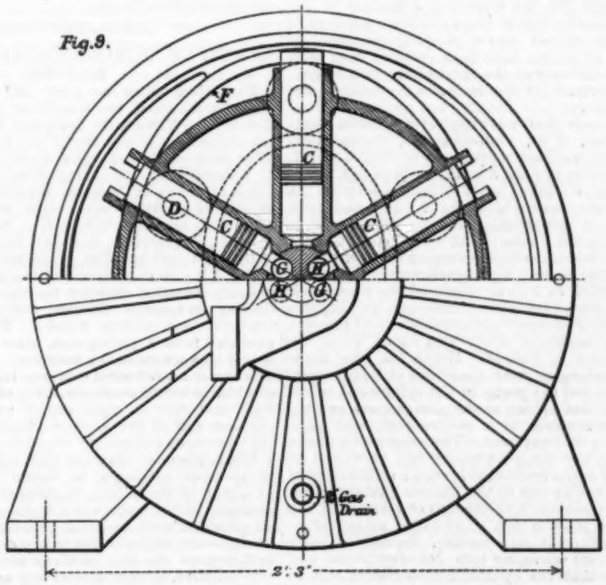


Fig. 10.

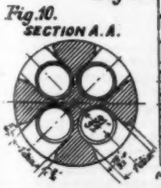


Fig. 11.

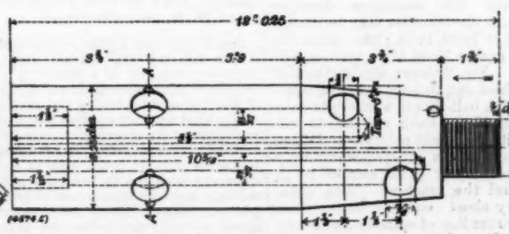
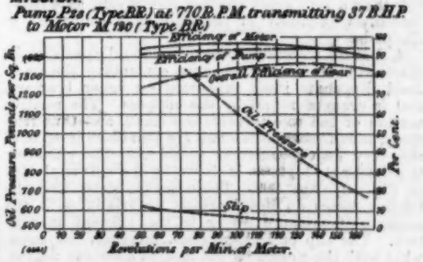


Fig. 12.

Fig. 13.

EFFICIENCY OF COMPAYNE HYDRAULIC TRANSMISSION.

Pump P12a (Type BR) at 710 R.P.M. transmitting 37 B.H.P. to Motor M 190 (Type BR)



without any sudden shock to the working parts. Probably the most important feature of the system in its present application is the power of being able to bring up the traverser exactly to its required position, or, as it is called, to "inch" it, either backwards or forwards, and so obtain the exact alignment of the rails. In this matter of "inching" the system has proved to be an unqualified success, and, we understand, has given complete satisfaction to Mr. Roger T. Smith, who decided to recommend this system for the purpose, after seeing other applications of it.

An electrically-operated emergency brake is fitted to each axle-shaft, and is operated by means of a switch interlocked with the controller, so that the brakes cannot be applied unless the controller-handle is in the "off" position. The electric motor is capable of developing 50 brake horse-power when running at about 710 revolutions per minute on a three-phase alternate-current circuit, of 440 volts 25 periods. Current is supplied to the motor from overhead wires, through trolley collectors mounted on a tower at one end of the locomotive. Each traversing-carriage is built up of rolled-steel sections and runs on sixteen wheels on four lines of rails. The eight centre wheels

are fitted with roller bearings, the outer wheels being bushed with gun-metal. The rails for carrying the wagons on the traversing carriages are of 71-lb. bridge section, set to a gauge of 4 ft. 8½ in. Each carriage is provided with a free bollard at each end for use when hauling wagons on or off by means of the capstan head on the locomotive. Spring buffers are fitted at the ends of the carriages and locomotive, and combined buffers and draw-gear at the centre.

The locomotive was specified to be capable of an average speed in either direction of 300 ft. per minute, measured over a length of track of 220 ft., when propelling or hauling one of the traversing carriages carrying a loaded wagon weighing 30 tons.

The acceleration, when starting under such conditions, is 0.5 ft. per second per second, so that a maximum speed of 440 ft. per minute is reached in 15 seconds. The locomotive is also capable of propelling itself with the above load together with the second traversing-carriage empty. Under normal conditions the capstan-head is capable of exerting a rope pull of 750 lb. at a speed of 300 ft. per minute, assuming that there is no slip on the rope; and this figure can be increased to 2000 lb.

TABLE GIVING RESULTS OF TESTS OF TRAVERSERS.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Number on Record.	Particulars of Operation and Net Load.	Direction.	Distance.	Time.	Average Speed.	Total Watt-Hours for Operation	Gross Load, including Passengers.	Distance Run.	Total Ton-Miles.	Watt-Hours per Ton-Mile.
			ft.	secs.	ft. p. min.		tons	miles		
1	Locomotive and one carriage light..	East to west	221.0	36.5	364	206.4	18.615	0.0419	0.78	265
2	Locomotive and one carriage+20 tons	Ditto	218.0	34.0	384	259.5	38.615	0 0413	1.59	163
3	Ditto Ditto	West to east	218.0	34.0	384	268.5	38.615	0.0413	1.59	169
4	Locomotive and two traversing carriages (20 tons on west carriage; east carriage light)	East to west	220.0	38.5	343	270.0	43.725	0.0417	1.82	148.5
5	Ditto Ditto	West to east	220.0	37.0	357	269.5	43.725	0.0417	1.82	148
6	Locomotive & west carriage+30 tons	East to west	206.0	38.0	326	301.5	48.615	0.039	1.89	1·9.5
7	Ditto Ditto	West to east	216.5	35.0	371	301.5	48.615	0.041	1.99	151.5

Very thorough tests have been made of the gear, and in Fig. 5, page 228, we reproduce a number of the autographic records taken under various conditions of working. The dotted curves, showing the input of power to the oil-pump, have been deduced from tests made of the efficiency of the three-phase motor used. The principal results of the tests are recorded in the table given above.

The Hele-Shaw gear was supplied by Messrs. Compayne, Limited, of 64, Victoria-street, Westminster. Views of the pump are represented in Figs. 6 and 7, and of the motors in Figs. 8 to 12, on page 229. The pump consists of a set of seven cylinders forming the arms of the star casting *a* in Fig. 7; this casting is mounted on a cylindrical valve *t*. This valve is stationary, but the whole set of cylinders can be revolved round this valve by coupling up the extension *u* with any form of motor. A plunger works in each cylinder, as indicated in Fig. 6. Each of the plungers is fitted with a cross-head on its outer end, and slippers *w*, *w* on these cross-heads are constrained to follow a circular guide eccentric to the axis about which the cylinder casting is rotated. Hence, as the latter revolves, the plungers work in and out of their respective cylinders, and the ports in the cylindrical valves are located so that so long as the plungers are moving out they are coupled to a suction-port, and when moving in, to a delivery-port. The eccentricity of the path guiding the plunger-slippers can be varied at will by means of the cross-head *k*, shown on the right of Fig. 7. By pushing this to the left the guide-ring can be brought concentric with the axis of rotation of the cylinders, and there is then no pumping action whatever. By pushing it still further, the suction ports of the valve are converted into delivery ports, and *vice versâ*, so that the hydraulic motor connected to the pump is reversed. When the eccentricity is small, the volume of oil delivered is also small, and the pressure can be increased accordingly. In this way a very great starting torque can, as already stated, be obtained in the oil-motors connected to the pump.

A feature to which attention should specially be directed is that the guide-ring controlling the cross-head slippers is itself supported on roller bearings, and is dragged round by the slippers. The relative motion of the two is therefore small, and thus frictional losses between the two are also small in spite of the very heavy pressures sustained. The efficiency is accordingly high, as is shown by the curves plotted in Fig. 13, page 229. These curves show that the friction losses do not increase materially with the increase of pressure owing to the efficient lubrication. The slip or leakage does, however, rise somewhat with the pressure, but not to a serious degree. The full horse-power was obtained on the trials through a range of speed from 50 to 160 revolutions per minute.

The oil-motor is based on the same general principles, and is illustrated in Figs. 8 and 9, on page 229. In these views the cylinder body is denoted by A, and this is coupled to the machine to be driven, and revolves itself on a central valve B. This valve, which is shown separately and to a larger scale in Figs. 10 to 12, has four ports, as shown. Of these G G are inlet ports and H H exhaust-ports. In this case the plunger C C makes two strokes for one revolution of the cylinder body. The adjustable guide-ring used in the pump is replaced by a fixed cam-path F, shaped to give a constant rate of flow, and the plunger cross-heads carry ball-mounted rollers in place of slippers. The cylinder casting is forced to rotate by the reaction of these rollers against the inclined surface of the guide.

The rate of rotation depends wholly on the volume of oil supplied per second by the pump. When the guide-ring of this pump is nearly concentric with the cylinder body, the volume of oil supplied is also small, and the motor turns slowly, but can exert a very large torque. By reversing the eccentricity of the guide-ring of the pump, the ports G G of the motor become exhaust-ports, and the ports H H inlet ports, so that the direction of motion is reversed.

Both pump and motor are accurately balanced, and all the parts in which accuracy is required are of simple cylindrical form.

MULTIPLE BORING-MACHINE FOR BOX-MAKING.

THE illustrations on page 232 show a machine, recently designed by Messrs. A. Ransome and Co., Limited, of Newark-on-Trent and London, for boring simultaneously a number of small holes in the parts of wooden boxes, and other work of a similar nature. If necessary, it will countersink the holes for the heads of screws at the same operation. The machine illustrated is fitted with eight boring-spindles, but other sizes are made to take four, twelve, and sixteen spindles, respectively, and any size can be provided with additional spindles, if desired.

Fig. 1 is a front elevation of the machine, and Fig. 2 is a side elevation showing the counter-shaft used for driving the spindles, different arrangements of which are illustrated in Figs. 3 and 4. Fig. 5, which is reproduced from a photograph, gives a good idea of the actual appearance of the machine. As will be seen, it consists of a substantial cast-iron standard, to the top of which is bolted another casting, extending equally to right and left at right angles with the standard. On each end of this casting a bracket is bolted, and the front ends of the two brackets are connected by a bridge-piece, so that the four parts form the sides of an open rectangle, as shown in Figs. 3 and 4. The tops of the castings forming the rectangle are all arranged to lie in the same horizontal plane, and are all provided with undercut grooves, into which the boring-heads can be bolted in any position. The front bridge-piece can also be fixed at any point on the side brackets, so that almost any arrangement of the boring heads is possible. The maximum distance from left to right at which the spindles may be placed is 29 in., and from back to front 14 in.; the minimum distance between the centre lines of a pair of adjacent spindles is 1½ in. Fig. 2 shows the method of driving the spindles, which run in long cast-iron bearings and are provided with ball-thrust washers to take the thrust of the boring-bits. Each spindle, it will be seen, is provided with two belt pulleys, and those in the back row are each driven independently by a quarter-twist belt from a long drum carried on A standards placed behind the machine. The other spindles are driven by short endless belts from the lower pulleys of the rear line of spindles, as shown in Fig. 2, and also indicated by the chain-dotted lines in Fig. 4. This arrangement enables the very high speeds necessary for the small boring-bits used to be obtained satisfactorily; the actual speed of rotation of the spindles is 4000 revolutions per minute. Each spindle is provided with a small chuck for taking bits up to ⅜ in. in diameter, with proportionate countersink, this being the largest size for which the machine is recommended.

The work-table is mounted on slides formed on the front face of the main standard of the machine, and is raised to feed the work up to the bits by means of a pedal-lever and adjustable rod, clearly shown in Fig. 5; stops are provided to facilitate the placing of the work in the correct position. The table runs on ball-bearings on the edges of the slides, which, as can be distinguished in the illustration, are grooved to form ball-races, and as the weight of the table is balanced by a weight formed on the end of the pedal, very little effort is necessary to move it. The vertical movement of the table obtained by the pedal is 2 in., and its height can be adjusted to the extent of 2 in. to suit different thicknesses of material by means of a turn-buckle in the rod connecting the pedal to the table. The height of the table can be arranged by the makers to take work of any depth up to 14 in. The weight of the machine illustrated is about 18 cwt., and the maximum power required to drive it is 4 horse-power.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—The improvement in the price of Cleveland pig-iron was well maintained last Wednesday afternoon, when 84s. 9½d. per ton was realised for cash and 85s. 4½d. one month sellers, closing at 84s. 10½d. cash and 85s. 4½d. one month—an increase of 4d. per ton over the morning's level. Business was restricted to 1500 tons. Considerable excitement prevailed on Thursday morning when the announcement was made that, as the Government had prohibited speculative dealings in pig-iron and other metals, it had been decided to close the market pending further developments. This suspension of business continued on Friday, when it was intimated that the following settlement prices would remain in force until further notice:—Scotch iron, 90s. 6d. per ton; Cleveland iron, 84s. 6d.; Cumberland hematite, 115s.; and standard foundry, 84s. 1½d. The market remained closed until yesterday (Tuesday) morning, but no official transactions took place, nor was any official report issued. Cash sellers were quoted, unofficially, at 85s. 6d. per ton, the settlement price remaining at 84s. 6d. No business was done again this morning, but cash sellers' quotations advanced to 87s. per ton, the settling price being fixed at 86s. 3d.

Scotch Steel Trade.—While much consternation followed the closing of the Glasgow pig-iron warrant market last week, there is every evidence that the Government's action in endeavouring to fix standard prices for all metals required in the making of munitions and other war material is nearly concluded, and, with the elimination of speculation in pig-iron, steel, &c., the chances are that prices may come down. Meantime, however, one cannot get away from the fact that the heavy shipping freights have been mainly responsible for the high cost of steel and all other metals, and, with the urgent necessity, consumers have had no other course than to pay the price demanded. Whether the Government will be able to solve the freight problem or not remains to be seen, for even as it is there is a decided upward tendency. As practically the whole of the local output is being concentrated on Government contracts, steel-makers show little disposition to quote other than the prices ruling at the moment, more particularly as it is anticipated that further restrictions may be put by Government on pig-iron, which, of course, is so closely allied to steel, &c. The ever-increasing demand for finished steel of all grades undoubtedly demands some arrangement to prevent the wholesale export of pig-iron. In all the works the greatest activity prevails, shell bars especially being in constant request. Meantime, no steel for private orders can be rolled without permission from the Ministry of Munitions. Prices keep steady, and 13*l.* 7*s.* 6*d.* is being quoted for steel ship-plates; 14*l.* 7*s.* 6*d.* for boiler-plates; with angles about 12*l.* 15*s.* per ton, all less 2½ per cent. discount.

Malleable-Iron Trade.—Malleable-iron makers are practically overwhelmed with orders just now, the bulk of their output being materials required principally for the home trade, and all this despite the increasing scarcity of good puddlers and all other classes of workmen. All things considered, the high prices are in no way unreasonable. "Crown" bars may be 14*l.* per ton, or even upwards, less 5 per cent.; while for export the price runs about 13*l.* 5*s.* net and upwards.

Scotch Pig-Iron Trade.—The dramatic suddenness with which the pig-iron market suspended operations last Thursday brought to a startling termination the extraordinary run of speculation which has so increased the price of Scotch pig-iron during the past few weeks. Something of the kind was not unexpected, and the Order in Council prohibiting the speculative dealing in pig-iron and other metals will, no doubt, be advantageous. Makers' iron continues firm in price, and at current rates those who have any quantity in hand are not specially desirous of selling, and consumers are only buying for their most pressing needs. Home sales, notwithstanding, are just about normal, and the export demand keeps quite fair. There is a great demand for Scotch hematite pig-iron, the consumption of which is extremely heavy, while forge qualities are moving away in good quantities, and foundry sorts are also in considerable demand. Prices of makers' (No. 1) iron keep steady at the advanced rates, the current quotations being as follow:—Langloan, 122*s.* 6*d.* per ton; Summerlee, 125*s.*; Clyde, Calder, and Gartsherrie, 127*s.* 6*d.* (all shipped at Glasgow); Eglinton and Glengarnock, 120*s.* (both at Ardrossan); Dalmellington, 118*s.* 6*d.* (at Ayr); and Shotts, 127*s.* 6*d.* (at Leith).

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The only problem remains the one of supplies. Collieries seldom had such large numbers of orders on hand for all qualities. Severe wintry weather has given a filip to the house-coal market. The output, however, is below the recent weekly average, and the inevitable result is a shortage all round, with prices firmly fixed at the maximum. Collieries are being pressed for deliveries of best steam and hard grades by contractors, railway companies, &c., but the demands are beyond their ability immediately to comply with. Here again prices are at the Government maximum, with even more advantageous terms obtainable on export account. The shipments to neutrals are on the small side, but large tonnage continues to go to French and Italian destinations. Gas companies are having a difficulty in securing adequate supplies of gas fuel, one reason being the better return when the coal is sold for bunkering which averages about a 20s. increase. Slacks, nuts, and cobbles are in great demand, and what little there is on the open market meets with a ready sale at the top quotations. Coke of all descriptions is firm at recent high rates. The difficulties with regard to railway transport still cause considerable delay in the delivery of fuel, but the Government intervention in the matter promises to have good results. The local committee appointed by the Ministry of Munitions to direct local supplies in an equitable and even manner has already done good service. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 6d. to 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. 6d. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—Realising the importance attaching to the production of high-speed steel, the Government departments are just now devoting a good deal of attention to the matter. There is no present danger of a shortage of supply, but with the ever-increasing demands, some regard must be had to the situation in the near future. Apart from the large quantities for home purposes, military and civil, it has to be borne in mind that the French and Russian engineering and munition establishments are almost entirely dependent upon the Sheffield works for tool-steel. America, the only neutral country which manufactures the commodity, cannot obtain all she wants for her own manufactures. British requirements are at present being amply met, but the Government scheme is to avert any untoward possibility. Mills and forges are being urged to accelerate output. Greater results would accrue if the rolling and hammering facilities were increased, as there are large quantities of raw or partly finished steel accumulating. The pig-iron market is practically featureless. Makers are now observing the Government maxima. Hematites are a shade easier. East Coast is 140s., plus cost of carriage, and West Coast brands 130s. The maximum of 87s. 6d., with delivery in Sheffield, is asked for Derbyshire and Lincolnshire foundry iron. Derbyshire forge stands at 85s., and Lincolnshire brands at half-a-crown dearer. Scrap continues to advance in price, and old steel rails are now 10s. dearer. The position with reference to billets is still unsatisfactory, and manufacturers are gratified to obtain even present requirements. Recent rates obtain except for soft basic, which is now 12*l.* 5s. to 12*l.* 10s. Wire-makers, who have "orders" booked for six months ahead, are consuming large quantities of billets. There is already some inquiry for sheep-shears as the Australian demands are being made earlier on account of the slowness of output and difficulties of transport. Prices are the highest in the history of the trade. To replace a German line large quantities of tinned-steel tablespoons and teaspoons are going to the Colonies and South America. The cutlery trade is "booming," but much overseas business has had to be sacrificed for War Office orders, which are on such a scale as severely to tax the resources of the industry. Manufacturers have conferred with the authorities in London to get staffs "reserved," otherwise recruiting will render workshops incapable of turning out sufficiently large supplies. The foreign mail includes indents for steel, files, vices and cutlery.

AMERICAN STEEL AND IRON.—The war has had the effect of increasing the external demand for American steel and iron, the exports for the ten years ended with 1915 inclusive coming out as follow:—

Year.	Tons.	Year.	Tons.
1906	1,325,740	1911	2,187,725
1907	1,301,979	1912	2,947,596
1908	964,242	1913	2,745,635
1909	1,239,709	1914	1,549,554
1910	1,557,943	1915	3,513,453

RAW MATERIAL FOR THE ENEMY.—We read in *La Revue Electrique* that the French Minister of Commerce and Industry has forwarded to the French Chambers of Commerce information to the effect that Germany and Austria-Hungary are now busy in accumulating in the United States stocks of material of prime necessity, since, when peace is declared, there will be a considerable demand for these goods and the prices ruling will be very high. The stocks are to be warehoused until the close of hostilities. They include, it is stated, wool, lard, fats, copper, tin, crude rubber, rubber air-tubes, cotton, oil, soap, tissues. The Minister adds that he has thought fit to transmit the information to the Chambers in order that the French commercial and industrial firms may take the necessary measures to cover themselves against a possible cornering of the products in question.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The proclamation of the Government, prohibiting gambling in warrants, and forbidding all but strictly legitimate business in makers' pig-iron, has checked trading very greatly, but the prevailing opinion is that the abolition of outside speculative operations in warrants will benefit genuine trading. For the time being buyers and sellers alike are acting with the greatest caution, and little business is passing. For home consumption the quotations of No. 3 g.m.b. Cleveland pig, No. 4 foundry, and No. 4 forge all stand at the fixed maximum of 82s. 6d. Definite prices for export are very difficult to fix. At least one sale of No. 3 for shipment abroad has been made at 87s. 6d., and the quotation varies from that price to 90s., though some makers are not disposed to sell at even the latter figure. No. 1 for export is understood to be about 5s. above No. 3, whilst No. 4 foundry is 1s., and No. 4 forge 2s., below the ruling quality. Merchants report very extensive inquiries from customers abroad.

Hematite Iron.—Fairly good inquiries are reported for hematite, but they appear to result in little business. Sellers have practically no iron to offer for sale for supply before the third quarter of the year, and many makers refuse to enter into further contracts at present, having committed themselves as far ahead as they care to. Nominally the market quotation for Nos. 1, 2, and 3 East Coast brands stands at 140s., and it is stated that Continental customers are quite prepared to pay that figure. Further substantial sales to France and Italy are confidently anticipated.

Stocks and Shipments of Pig-Iron.—To meet current needs stocks of pig-iron are being steadily drawn upon. There is practically no iron lying at makers' yards, and the only stock of moment in existence is the Cleveland pig-iron in the public warrant stores, where the quantity held now stands at 77,410 tons, of which 74,955 tons is No. 3 quality, and 2455 tons other kinds of iron deliverable as standard. Since the beginning of the month the stores have been reduced by 5781 tons, 5451 tons of No. 3 and 330 tons of standard iron, having been withdrawn. Shipments of pig-iron from the port of Middlesbrough are, under the conditions prevailing, on a very satisfactory scale. So far this month they reach 16,172 tons, as compared with 14,635 tons to the same date last month, and 3630 tons for the corresponding part of March, last year.

Foreign Ore.—In foreign ore, interest centres in the circular issued by the Ministry of Munitions, urging that normal business proceed pending some settlement as to the question of price, and pointing out that the settlement will be retrospective to March 3. Consumers, however, are fairly well bought, are carrying fairly large stocks, and are not inclined to enter into further contracts just now. Sellers continue to take a firm stand, and market rates are based on 42s. 6d. ex-ship Tees for Rubio of 50 per cent. quality. Freights Bilbao-Middlesbrough are in the neighbourhood of 26s. Imports of foreign ore to the Tees to date this month are officially given at 16,585 tons.

Coke.—There are no new features in coke. Good foundry kinds for shipment run from 40s. to 42s. 6d. f.o.b. For local use the demand is rather heavy, and business continues at the fixed maximums for home consumption of 28s. at the ovens for average blast-furnace kinds, and up to 30s. 6d. at the ovens for qualities low in phosphorus.

Manufactured Iron and Steel.—There is little new to report concerning the various branches of the finished iron and steel industries. Government work continues to monopolise the attention of manufacturers, and little attention is paid by them to private business. There are, however, numerous ordinary commercial inquiries in the market, and buyers are prepared to pay considerably above recognised rates for descriptions without fixed maximum. Higher rates are being asked for packing iron and for iron and steel rivets. The following are among the principal market quotations:—Packing iron (parallel), 10*l.*; packing iron (tapered), 11*l.* 15s.; iron ship-rivets (three-quarter diameter), 16*l.*; steel girder-rivets (three-quarter diameter), 17*l.* to 17*l.* 10s.; common iron bars, 13*l.* 10s.; best iron bars, 13*l.* 17s. 6d.; double best, 14*l.* 5s.; treble best, 14*l.* 12s. 6d.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 10s.; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel joists, 11*l.* 2s. 6d.; steel strip, 13*l.* 10s.; steel hoops, 14*l.*; and heavy steel rails, 10*l.* 17s. 6d.—rails not f.o.b., steel ship-building material net at works, and all other descriptions less the customary 2½ per cent. discount.

ENTRANCES TO JAPANESE PORTS.—The number of steam vessels which entered Japanese ports from abroad in 1914 was 9451, representing an aggregate of 23,584,482 tons. The corresponding entrances in 1913 were 9888 vessels, representing 24,658,874 tons; in 1912, 8957 vessels, representing 21,633,818 tons; in 1911, 8576 vessels, representing 19,993,397 tons; and in 1910, 9442 vessels, representing 20,073,680 tons. The number of sailing vessels which entered Japan in 1914 was 294, representing 47,157 tons, as compared with 353, representing 61,464 tons, in 1913; 428, representing 66,373 tons, in 1912; 430, representing 59,969 tons, in 1911; and 1726, representing 100,107 tons, in 1910. Of the steam vessels which entered in 1914, 1875 were British, representing 6,697,859 tons; 6307 Japanese, representing 12,711,905 tons; 184 American, representing 1,286,400 tons; 355 German, representing 1,281,973 tons; and 396 Russian, representing 667,009 tons. It will be seen that shipping movements to Japan were not materially affected by the war in the second half of 1914.

NOTES FROM THE SOUTH-WEST.

Cardiff.—A continued scarcity of tonnage has restricted steam-coal shipments, and although collieries supplying the authorities have been kept working regularly, there have been frequent stoppages, chiefly in consequence of failure to obtain wagons. There is little prospect of tonnage increasing at present, and the Government has restricted export licences for neutral countries in order to enable the allied nations to secure supplies more readily as well as to provide for home consumption. Best Admiralty large steam coal has been, to some extent, nominal; ordinary qualities have been making 30s. to 31s. per ton; best bunker smalls, 17s. to 17s. 6d.; and cargo smalls, 10s. to 13s. per ton. Bituminous coal quotations have been:—Best households, 23s. to 24s.; good households, 21s. to 22s.; No. 2 Rhondda large, 27s. to 28s.; and No. 2 smalls, 16s. to 17s. per ton. The latest quotation for patent fuel has been 35s. to 36s. per ton. Special foundry coke has brought 50s. to 52s. 6d.; good foundry coke, 47s. 6d. to 50s.; and furnace coke, 35s. to 40s. per ton. As regards iron ore, Rubio has made 38s. to 40s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

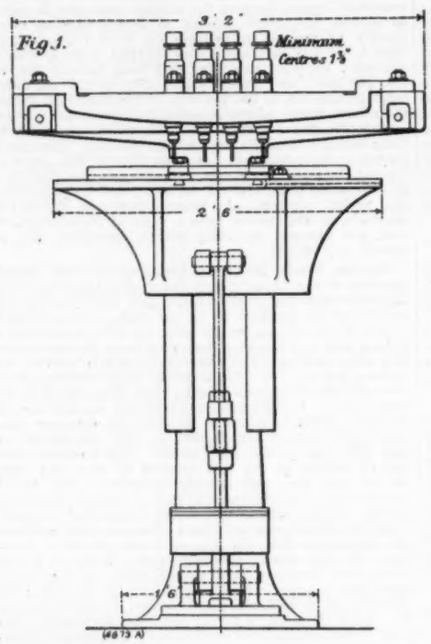
Western Trade Matters.—Presiding at the annual meeting of the Consolidated Cambrian, Limited, Lord Rhondda said the profits of the past year justified an increase of the dividend to 15 per cent. per annum, and he hoped the increase would help the 5000 shareholders to bear with less hardship the trying times through which they were passing. The amount required to provide the increase was 37,774*l.* The relations of the company with its employees were more friendly than they had been for some years. Health insurance showed an increase of 95,484*l.*; while, in addition to this, the company had voluntarily contributed 21,562*l.* for the dependants of men who had joined the Colours. The average earnings of colliers in the last quarter of 1915 had been 11s. 9d. per day, and colliery proprietors had found that the cost of producing coal had a continued tendency to rise. American coal was being increasingly shipped to the Mediterranean and South America, and last year coal shipments from the United States increased threefold.—At the annual meeting of the Redcroft Steam Navigation Company, Mr. Lewis, Loughor, who presided, stated that the year's profits amounted to 117,263*l.*; an allowance of 55,000*l.* was made to meet the excess-profits tax, and a dividend of 20 per cent. was declared for the year.—The shareholders in Graham's Navigation (Merthyr) Collieries, Limited, were informed by the chairman (Mr. T. C. Graham) that the output of coal by the company in 1915 was the largest in the history of the concern, but it would have been at least 20 per cent. more if colliers had worked full time all through the year; the dividend for 1915 was fixed at 12½ per cent. —Bristol Channel transport shore workers have received advances in wages to the amount of nearly 100,000*l.* per annum—The Cardiff Junction Dry Dock and Engineering Company has declared a dividend at the rate of 10 per cent. per annum, free of income tax.—Mr. H. R. Price, who has retired from the secretaryship of the Brecon and Merthyr Railway, will continue to act as general manager.—The Western Counties Shipping Company, Limited, has announced a dividend for the first six months of its trading at the rate of 20 per cent. per annum, free of income tax.—In connection with recent negotiations, under which the Cardiff Channel Dry Docks and Pontoon Company, Limited, acquires the control of the Barry Graving-Dock and Engineering Company, Limited, it may now be stated that a meeting has taken place between the chairmen of the respective companies and their solicitors, and that, as a result of the conference, cheques were handed to the shareholders in the Barry Company who had agreed to sell their holdings. It was stated that 96 per cent. of the Barry shareholders had assented to the controlling sale.—At the annual meeting of the Great Western Colliery Company, Limited, the chairman (Mr. C. J. Lowe) said the cost of coal production had been increasing for the last few years at an alarming rate; but the demand for coal had enabled coal-owners to obtain proportionate prices. The company had made substantial progress with a new colliery at Cwm. The revenue balance of the undertaking for the year was 143,080*l.*—With reference to recent decisions it is announced that the undertaking of Mordey, Carney and Co., Limited, is to be carried on as a separate concern under the direction of Sir F. Shearman.—The Bedwas Navigation Colliery Company, Limited, returns its profits for 1915 at 35,983*l.* The colliery has now been placed upon a profitable basis, and it is considered that there is reasonable ground for anticipating a dividend upon the ordinary shares next year; the opening out of the colliery has been much more difficult than had been anticipated, but the workings are now capable of a much larger output.—The control of the Celtic Collieries, Limited, is to be entrusted to a Board of which Lord Rhondda will be chairman; the sale of the coal produced will be in the hands of Messrs. Lysberg, Limited, who are agents for the Glamorgan Coal Company, Limited, the Chargeurs Français, and a number of other companies.—Tin plates are at record prices, and the tendency is still upward, plates having been sold at Swansea at 27s. per box. Some works are, however, experiencing difficulty in obtaining raw material, and the trade is not considered to be in a very healthy condition.

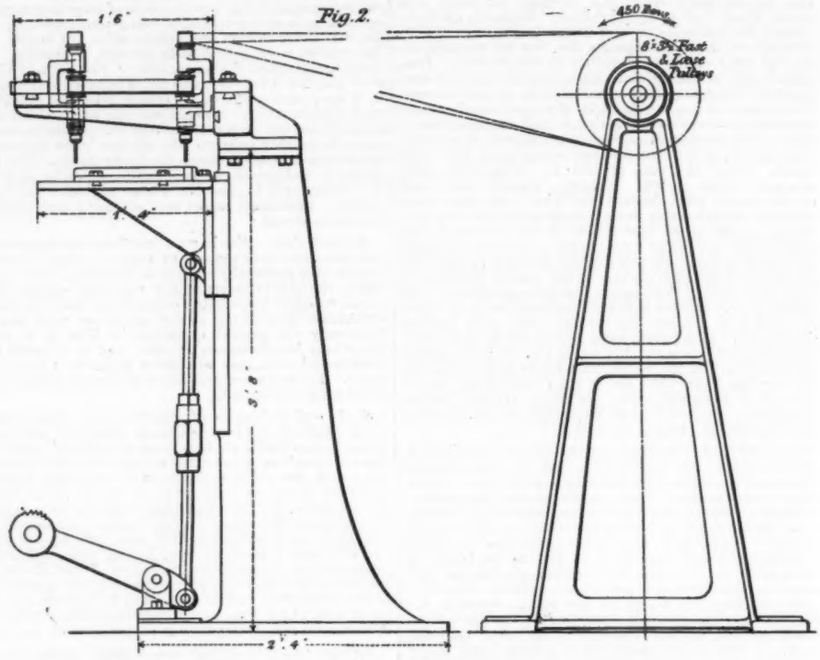
RUSSIAN COAL.—Russia's production of coal during 1913 amounted to about 31,000,000 tons, and in 1914 to 28,000,000 tons. As the Polish districts, which in 1913 yielded 22 per cent. of the aggregate output, are now occupied by Germany and Austria-Hungary, Russia's production of coal for 1915 cannot be estimated at more than 20,000,000 tons.

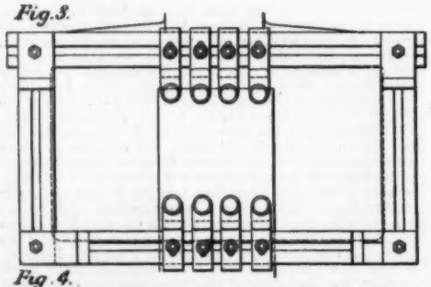
MULTIPLE BORING-MACHINE FOR BOX-MAKING.

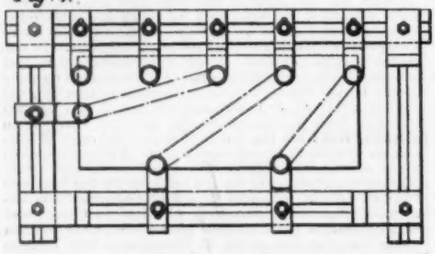
CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(*For Description, see Page* 230.)









RESTRICTIONS IN DEALINGS IN METALS.—With reference to the Regulation published in the *London Gazette*, dated March 1, 1916, as 30b of the Defence of the Realm Regulations (Consolidated), the Ministry of Munitions wishes it to be clearly understood that the object of this Regulation is to stop speculation in metals generally, and not to restrict legitimate trading. In view of the representations which have been made to the Ministry of Munitions, the following particulars are published for general information and guidance:—(1) The Regulations will not be enforced in the case of purchases made outside the United Kingdom until the metal actually reaches this country. (2) Export orders and sales to allied or neutral countries through authorised channels will be treated as consumers' orders. (3) It is permissible for merchants, warehousemen, and retailers to replace metals sold after March 1, 1916, by the purchase of an equivalent quantity of the same metal, but not more, although the metal so purchased may not be the metal actually delivered against the sale. (4) Transactions will not be permitted, except under special licence from the Ministry of Munitions, in the following:—Scrap from high-speed steel; scrap from copper; scrap from brass. Transactions in other scrap metals do not require a licence. (5) Consumers may buy for their own consumption only.

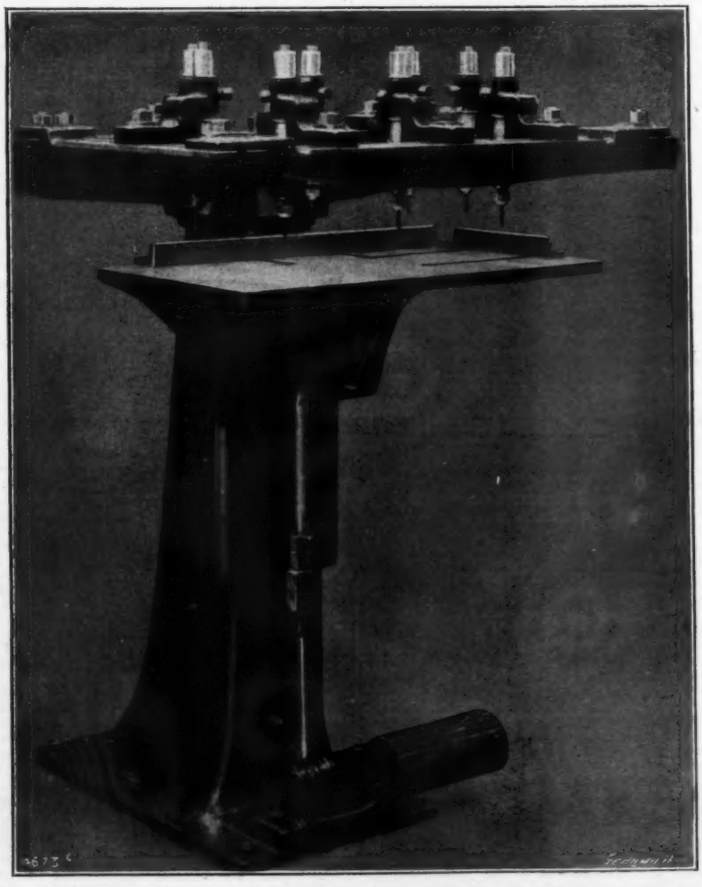


FIG. 5.

GRINDING MACHINES.

(*For Description, see Page* 223.)

Fig.301.

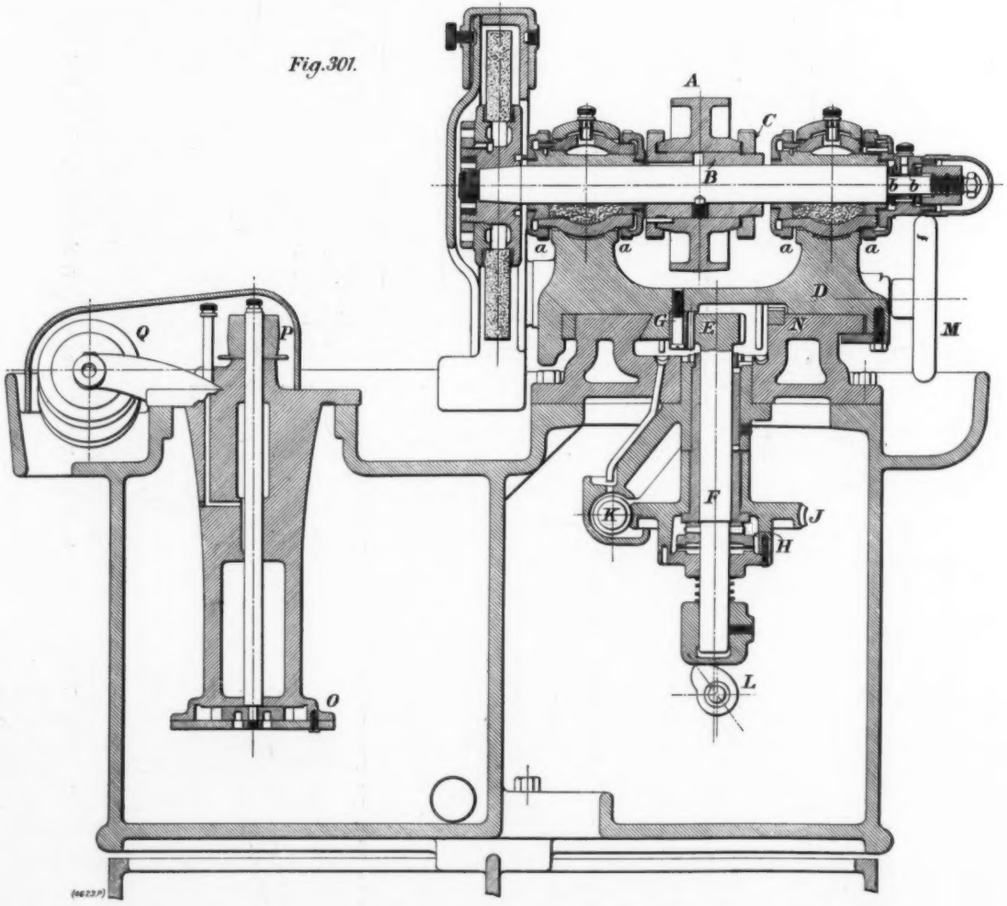


FIG. 301. SECTION THROUGH WHEEL-HEAD, BED, AND TANK OF PLAIN GRINDING-MACHINE, BY THE BROWN AND SHARPE MANUFACTURING COMPANY, PROVIDENCE, R.I., U.S.A.

Fig.302.

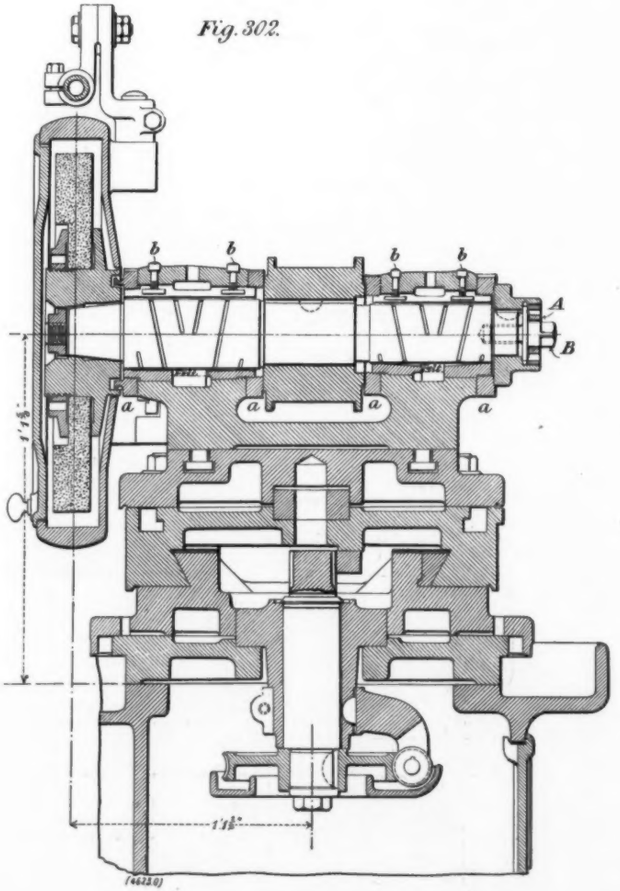
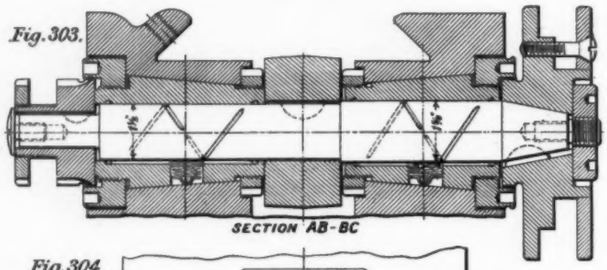


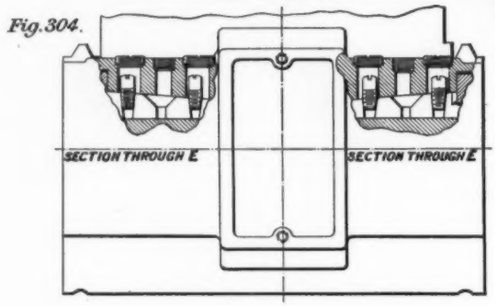
FIG. 302. WHEEL-HEAD AND SLIDES, BY THE CINCINNATI GRINDING COMPANY, CINCINNATI, OHIO, U.S.A.

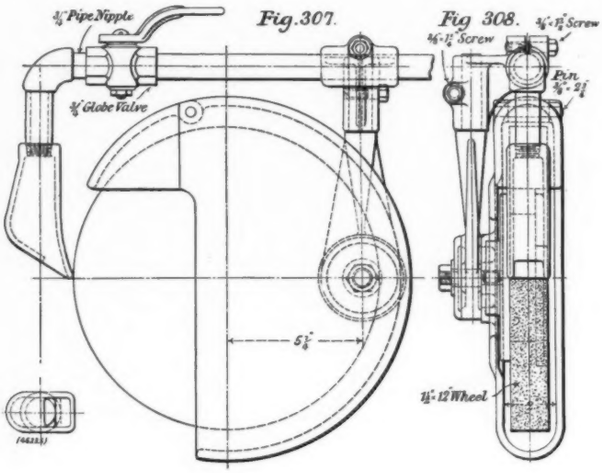
(*To Face Page* 222.)

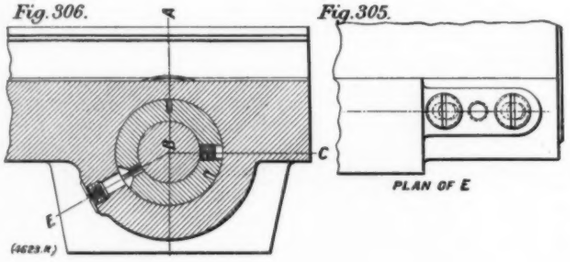
GRINDING MACHINES.

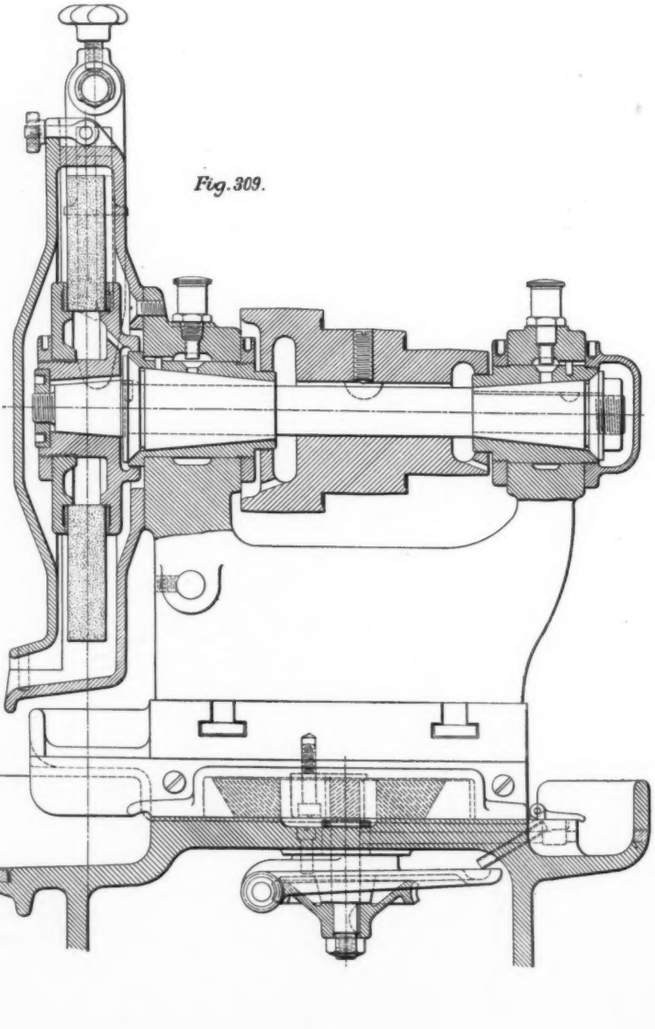
(*For Description, see Page 223.*)

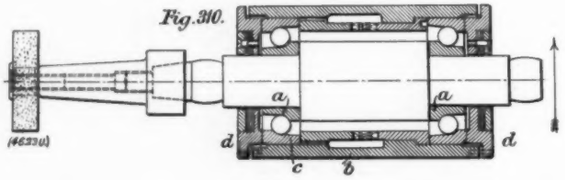












FIGS. 303 TO 306. WHEEL-SPINDLE, BY THE BATH GRINDER COMPANY, FITCHBURG, MASS., U.S.A.

FIGS. 307 AND 308. DETAILS OF HOOD AND WATER SUPPLY.

FIG. 309. SECTION THROUGH WHEEL-HEAD, HOOD, AND WASTE-WATER DISCHARGE; THE NARRAGANSETT MACHINE COMPANY, PROVIDENCE, R.I., U.S.A.

FIG. 310. WHEEL-SPINDLE, BY THE AUTO-MACHINERY COMPANY, LIMITED, COVENTRY.

(*To Face Page 223.*)

30-TON TRAVERSER FOR THE GREAT WESTERN GOODS STATION, MOOR-STREET, BIRMINGHAM.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, ENGINEERS, BATH.

(*For Description, see Page 228.*)

Fig. 2.

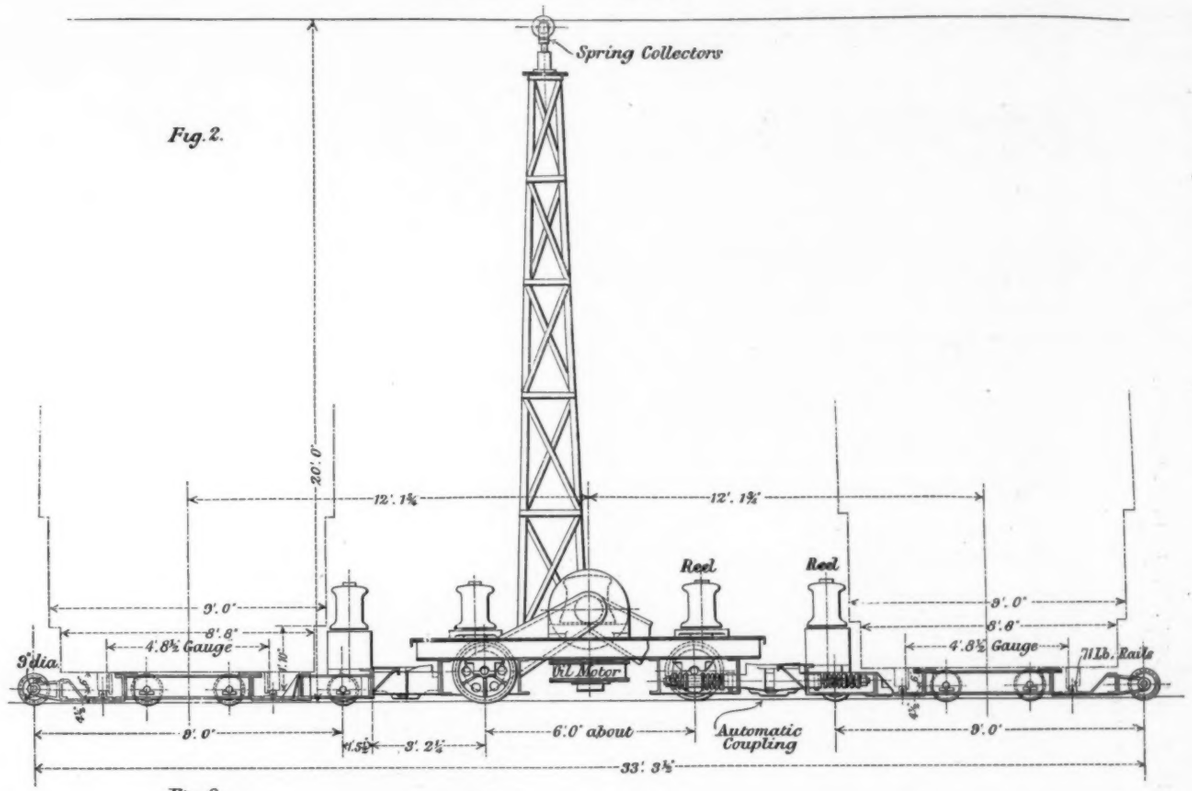
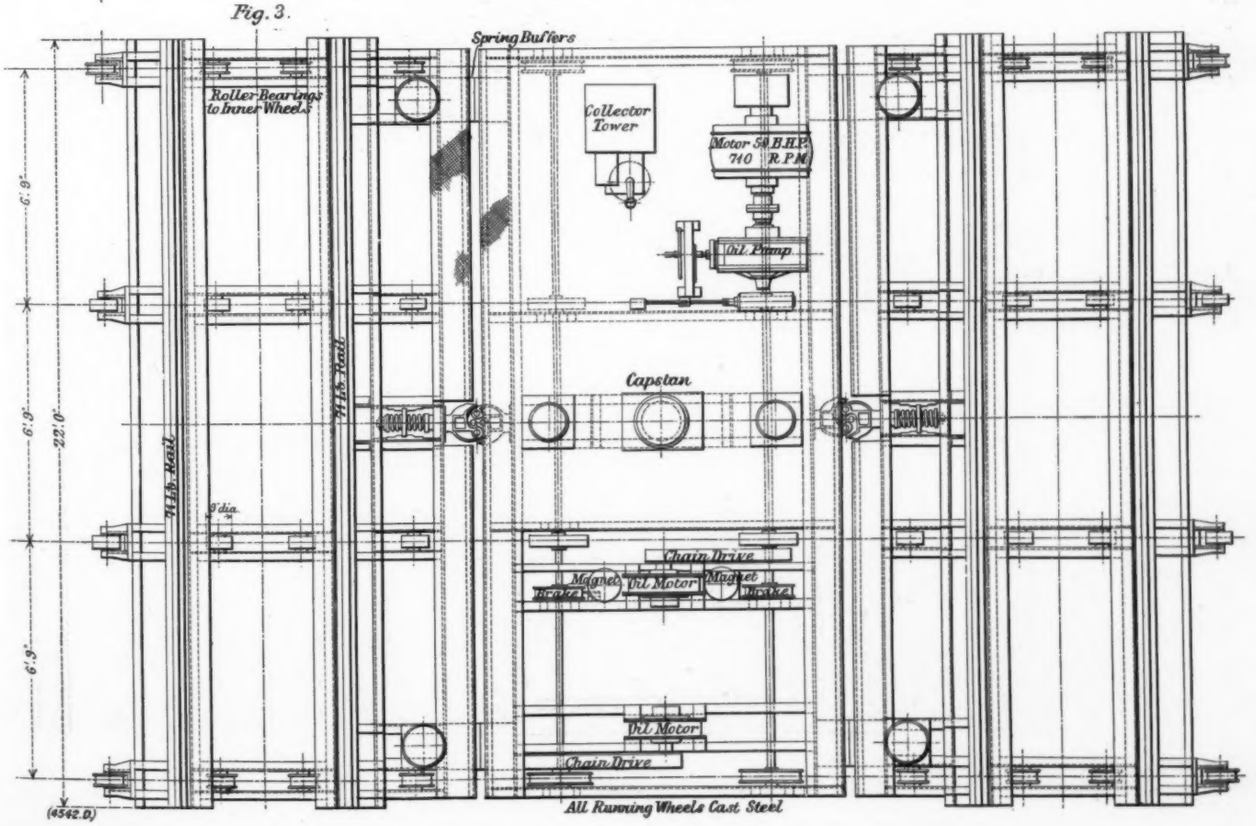


Fig. 3.



(*To Face Page 228.*)

30-TON TRAVERSER FOR THE GREAT WESTERN GOODS STATION, MOOR-STREET, BIRMINGHAM.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, ENGINEERS, BATH.

(*For Description, see Page* 228.)

FIG. 4.

(*To Face Page* 229.)

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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The Publisher desires to notify subscribers to "ENGINEERING" in the East who did not receive their copies of "ENGINEERING" of the issues of December 17, 1915, and February 25, 1916, that they may have gone down with the mails in the S.S. "Persia" and S.S. "Maloja." A few copies are still in stock of each of these issues, and may be secured at the ordinary rates, plus postage.

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With Two One-Page Plates of GRINDING-MACHINES and Two One-Page Plates of a 30-TON TRAVERSER FOR THE GREAT WESTERN GOODS STATION, MOOR-STREET, BIRMINGHAM.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, March 10, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: 1. "Experiments Illustrating the Flow of Heat in Conducting-Sheets," by Mr. S. Skinner, M.A. 2. "The Absorption of Gas by a Quartz Vacuum-Tube," by Mr. R. S. Willows, M.A., D.Sc., and Mr. H. T. George, M.A.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, March 13, at 7.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough. The following paper will be read and discussed:—"Fuel Economy from a National Standpoint," by Professor WM. A. BONE, London.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, March 14, at 8 p.m., at the Rooms, 207, Bath-street, Glasgow, when Dr. Charles Chree, F.R.S., will deliver his Kelvin lecture, entitled "Terrestrial Magnetism." This lecture relates to results deduced from the magnetic observations made by the last Scott Antarctic Expedition, and Dr. Chree will show lantern-slides of some of the actual records.

THE CIRCLE OF SCIENTIFIC, TECHNICAL, AND TRADE JOURNALISTS.—Tuesday, March 14, at 8 p.m., in the Hall of the Institute of Journalists, Tudor-street, Blackfriars, London, E.C. Discussion on "The Sphere of the Scientific and Technical Press in Relation to Technical Education and Industrial Research." Dr. William Garnett (late Educational Adviser to the London County Council) will open the discussion by an introductory paper.

THE JUNIOR INSTITUTION OF ENGINEERS: MIDLAND SECTION.—Tuesday, March 14, at 7.30 p.m., at the Imperial Hotel, Temple-street, Birmingham. Paper by Mr. C. H. Ayres on "The Application of Alternating Current to Workshop Equipment."

THE NOTTINGHAM SOCIETY OF ENGINEERS.—Wednesday, March 15, at 7.30 p.m., at the Welbeck Hotel. Mr. H. L. Reason, of Messrs. John Russell and Co., Limited, Birmingham, will give a paper on "Brass-Foundry Practice," which will be illustrated by lantern-slides. The chair will be taken by Mr. C. Liddell Simpson, M.I. Mech. E., and Mr. W. Ralph Bates will occupy the vice-chair.

THE INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.—Wednesday, March 15, at 7.45 p.m. Adjourned discussion on "Suggested Applications of Science to Warfare."

THE CONCRETE INSTITUTE.—Wednesday, March 15, at 5.30 p.m., at 296, Vauxhall Bridge-road, Westminster, S.W. A paper will be read by Mr. W. G. Perkins, M.C.I., District Surveyor of Holborn, entitled "Some Examples of Dangerous Structures."

THE ROYAL SOCIETY OF ARTS.—Wednesday, March 15, at 4.30 p.m. A paper on "Forestry and the War" will be read by Mr. Edward Percy Stebbing, F.L.S., F.R.G.S., Head of the Department of Forestry, University of Edinburgh.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, March 15, at 7.30 p.m., at the Surveyors' Institution, 12, Great George-street, Westminster. A lecture on "The Meteorology of the Globe in 1911" will be delivered by Sir Napier Shaw, F.R.S.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, March 15, at 7 p.m., at the University, Edmund-street. Mr. W. J. S. Peck, M.I.E.E., will read Mr. N. W. Storer's paper entitled "The Use of Continuous Current for Terminal and Trunk-Line Electrification."

THE FARADAY SOCIETY.—Wednesday, March 15, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. An informal discussion on "Methods and Appliances for the Attainment of High Temperatures in the Laboratory." Dr. J. A. Harker, F.R.S., of the National Physical Laboratory, will open the discussion, over which Sir Robert Hadfield, F.R.S., the President of the Society, will preside.

THE IPSWICH ENGINEERING SOCIETY.—Thursday, March 16, at 8 p.m., at the Museum, High-street. Lecture by Professor Humboldt Sexton, F.I.C., F.C.S., Emeritus Professor of Metallurgy, the Royal Technical College, Glasgow, on "Fuel Economy and Gaseous Fuel."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 16, at 8 p.m. "The Use of Direct Current for Terminal and Trunk-Line Electrification," by Mr. N. W. Storer.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 17, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Paper on "The Composition of the Exhaust from Liquid-Fuel Engines," by Sec. Lieut. Robert W. Fenning, B.E. (T.), B.Sc., D.I.C., of London.

ENGINEERING.

FRIDAY, MARCH 10, 1916.

PREPARATIONS FOR PEACE.

THE late George Augustus Sala used to relate how, when living in Paris in his youth, he met an old gentleman who had been resident in that city all through the Reign of Terror. Naturally, he seized the opportunity to attempt to learn at first hand something of the tragical events of the Revolution. He was, however, disappointed. His new acquaintance blandly told him that he had little or no knowledge of the events of that time, because his whole attention was then given up to conchology, and he had no leisure to devote to politics. To this generation, which regards the French Revolution as the most amazing and pregnant episode in European history, the tale seems almost incredible. It would, however, be interesting to know how many persons there are in this country who are as blind and deaf to the signs of the times as was the man in question. Of the war itself none of us can know much except the broad results, for all the details are very properly guarded as secrets, and there are very few men who know them all. But there is enough of speculation and interest as to what will follow the war to fill every mind. On all sides changes are being wrought that will compare with those which resulted from the great upheaval in France at the end of the eighteenth century. Old ideas and beliefs are gradually fading, and are being replaced by a new growth, which will have immense results—whether for good or evil it is difficult to say. Every age is the heir of shibboleths which have all the appearance of soundness, but which are quite empty. Under ordinary conditions they survive long, but in times of stress and strain they collapse, and new formulæ have to take their place. We are now seeing that process going on all around us, and it presents features far more fascinating than conchology, or any other science that deals with dead matter. Social customs and conventions are in the melting-pot, and the question of all others is, what shape they will be cast in eventually. The form will largely be determined by events, but it lies with each of us to do what he can to secure that the transformation shall be made with the minimum of heat and explosion.

Already a good many minds are at work on the very difficult problem of bridging the period between the cessation of hostilities and the complete restoration of industrial life. On Wednesday of this week the subject was brought forward in two very different ways. In the first, the Lord Mayor and a deputation laid before Mr. Asquith the resolutions carried at the great public meeting held at the Guildhall on January 31, which called for the appointment of a Minister of Commerce, who should be a business man, and who should be assisted by an advisory committee of business men. The second was an address by Mr. Harold Cox to the Institution of Civil Engineers, on "Industrial Development." It cannot be said that the Lord Mayor's proposals met with a very cordial reception from the Prime Minister. Mr. Asquith did not favour the multiplication of ministries, and he displayed no enthusiasm for confiding business affairs to business men. He mentioned, however, that a Peace Book was being prepared, which would enable the various commercial and other interests of the country to meet the new state of things created at the termination of the war, not in the haphazard improvised fashion which has so often been the rule in the past, but with adequate consideration and preparation. If the book will do that, it will certainly be welcomed. Mr. Asquith, however, likened it to the War Book which had been prepared some years ago. We have not seen this book—we believe it is not a public document—but if the successful way in which the Expeditionary Force was sent abroad was due to it, many merits may be ascribed to it. But the whole book seems to have rested upon the gigantic fallacy that a force of 180,000 men was an adequate contribution on our part to a European war. If the Peace Book is to take no broader outlook than that, we fear it will not prove of much service.

The speech of Mr. Harold Cox at the Institution of Civil Engineers was entirely an innovation, and in that respect it was an excellent sign. It showed that the oldest technical society is still in a process of development, and is ready to alter its procedure to fit its environment. Industrial development in its broader aspects has not hitherto formed a subject for consideration by the Institution, except sometimes incidentally in presidential addresses. To-day it is the most pressing matter that could be brought forward, and the Council are to be congratulated in securing the assistance of such a distinguished economist. The theme of Mr. Cox's discourse was the necessity of engineers making preparations ahead of the time when we shall have four millions of men returning and clamouring for work, and thousands of munition workers, largely women, discharged from their employment and told to return to the kitchen, the nursery, and the school-room. The situation, unless carefully prepared for and wisely and tactfully handled, contains the imminent possibility of an industrial revolution. How long we have in which to make our arrangements we do not know, but it is difficult to believe that it can be more than eighteen months. That is little enough when we consider how serious are the issues. Even if we rule revolution out of the question, it would be most deplorable if the men who have fought and bled for us found themselves on their return with no work and no wages. They might then very properly ask what use we had made of the security which they had earned for us.

The strained relations of employees and employers have long been a commonplace of newspapers, and probably always will be. But there will certainly be a change after the war; for better if sufficient care be given to the subject, and for worse if it be allowed to develop haphazard. For the first time in the British Army the working and the capitalist classes have been found together in

(To Face Page 239)

the ranks as privates. Of course, the former largely predominate; but still there have been enough of the latter to enable both classes to get to know each other in a way which is impossible in civil life. Further, large numbers of officers are really no richer than a capable mechanic, and have never imbibed the ways and ideas which are generally described as militarist. There is no barrier, other than the necessity of maintaining discipline, between them and their men. In the actual fighting the officers have striven to secure the posts of danger, while their men have time after time sacrificed themselves to shield or rescue their officers. If anything can soften the asperities which exist between the classes, such experiences as this should do it. The seed of a better state of affairs has been sown. It has been, however, under artificial conditions, and the growth will certainly receive a check on the return of the Army. How severe this check will be depends largely on conditions to be met with. If these are bad, if cold and privation have to be endured, the belief might easily arise that the good-fellowship of the capitalist classes on the tented field was merely a device to secure the services of the working men in a new capacity. If such an idea got abroad, it would be more fatal to industrial peace in the future than all the socialistic fallacies ever uttered.

Among the suggestions put forward by Mr. Cox was the preparation of plans of work to be undertaken immediately peace was declared. We have ourselves already urged this idea at considerable length,* but we have not heard that the Local Government Board has brought pressure to bear on the municipalities in order that they may be ready to absorb as much labour as possible as soon as it is released. This is a matter in which that body might well give a lead to the public. It has not been overwhelmed with new work, like the Board of Trade, and its advice would carry great weight. The great railway and dock companies will certainly put their new works in hand as soon as possible after the war, but they are hampered in the preparation of plans by so many of their staff having gone to the Front. Mr. Cox found great cause for hope for the future in the sound state of our finances. He stated that in 1915 our foreign trade was as great as it was six years ago measured by value, and as great as it was twelve years ago measured by volume or weight. If he included imports in his figures, and we believe he did, it is to be remembered that much of these has been paid for out of capital, and that most of us could assume an air of prosperity if we were to use up our savings or to mortgage our future earnings. Our exports offer just now a better guide to our position than do our imports. In normal times our imports are a measure of our spending power, for they are paid for out of income. A time of war is, however, always a period of commercial prosperity, the relapse generally comes a year or two after, and it is for that we have to prepare. It cannot be said that Mr. Cox was able to shed much light on the subject. His preventative of disaster lies in greater efficiency in the worker, and greater consideration on the part of the employer. But he admitted no one could define what was the just share of the proceeds of a business to be assigned to capital, management and labour, and until this can be settled one or more of the parties is sure to feel aggrieved. It is perfectly clear that if labour were more efficient it might be paid higher wages. It would then not only be able to have a higher standard of living, but its enhanced spending power would lead to an augmented home trade. It seems remarkable that it should still be necessary to insist that high wages can only be attained by high efficiency on the part of the worker. But that truth, self-evident as it seems, has not yet been accepted by the trade unions, which oftener seek to keep up wages by restriction of output. Even now, in a time of national peril, this policy is not wholly abandoned. Mr. Cox was full of sympathy for those who live in dull streets, with few pleasures, and pass their days at monotonous tasks. He would like to see them better housed, better fed, and with ampler joys, and so should we all; but this end can never be attained by creating an artificial scarcity of labour. Increased wages without increased output only puts up prices all round, and the workman finds himself no better off although in receipt of more money.

* See ENGINEERING, May 28, 1915.

There is nothing more pathetic in industrial history than the conflict of labour with machinery. It has existed for a hundred years or more, during which time there has been a constant progress in comfort and well-being among the working classes. Yet even to-day the machine is looked upon with suspicion by the workman as something designed to filch his living from him. Curiously it is only the novel machine that is the subject of hostility. If men were asked to do the old heavy work with chisel and file that obtained fifty years ago, they would indignantly refuse and ask why there were not planing-machines and shapers to do the job. They do not object to a condition of affairs which has become established and has lightened their toil. But an appliance that threatens even temporarily to produce a greater output fills them with apprehension. All the efforts of the economists seem to have failed to spread clearer ideas on this subject; but until more accurate views prevail, it is difficult to see how the amelioration of the lives of the working classes is to be achieved. As a general proposition, a man gets about what he has earned in whatever class he is, and the way to get higher pay is to produce more.

Mr. Cox is by no means satisfied with the efficiency of the employer. Certainly the creation of the large munition works has shown what can be achieved with what was recently looked upon as impossible means. It has shown that care expended on lighting, heating, and the provision of good food is fully repaid by increased output. Of course, the best type of employer has long known this, but the lesson is still to be learned by many. Suggestions for the provision of more comfort and conveniences for the workers are often met with the remark that they will earn no gratitude. If they attract a more temperate and intelligent class of men, they will earn dividends, which, after all, is the purpose of manufacturing. There is still much that can be done by employers as a class to raise the efficiency of their men, but it is scarcely by small changes of this kind that the dangers of the next few years are to be averted. It will need the combined action of politicians, financiers, merchants, and manufacturers to steer us through the dangers before us. Wise legislation and an active search for trade can do much; but the most effective means would be moral. The three million men will come back from the Front very different from what they went. After looking upon death and wounds for months, their scale of values will have altered, and they will see old subjects in a new light. What that will be exactly no one can foresee. But an opportunity will be created for someone to lead them in a different path. Whether it will be the politician, the economist, or the socialist no one can say; but we are certain the socialist will try. It is to be hoped that the economist will also make the attempt to seize the opportunity.

THE STRENGTHENING OF THE NAVY.

IN what Colonel Churchill characterised as a "calm and broad survey" of the vast activities of the Admiralty in the House of Commons on Tuesday, Mr. Balfour succeeded in creating a spirit of confidence in the House which we doubt not will extend to the whole country. There has been recently a tendency to imagine that great things are happening behind the veil of secrecy which shrouds the shipbuilding operations of the enemy. We ought to prepare for the maximum augmentation of German naval force, but not for any exaggerated estimate of the possibilities. The shipbuilding resources of Germany are not by any means so great as those of Britain, and although the workers there may apply themselves to operations a little more diligently, Germany cannot exceed, even if they approach, in volume that which is being achieved in this country. Their ingenuity and resource are great, but the experience and originative capacity of our naval designers are quite equal to achieve now, as in the past, a superiority in the form of that force which we hoped to have tested in a general engagement in the North Sea. The other factor is that the continuous work at sea of our ships involves greater wear and tear, and therefore more extensive repairs than in the case of a fleet moored in harbour. But, on the other hand, deterioration, alike in *personnel* and *matériel*, can be dangerously great during prolonged inactivity. Thus, while we discourage exaggeration, we must continue with diligence to apply every faculty, mental and physical, towards the strengthening of our Fleet for the hoped-for engagement.

The occasion of Mr. Balfour's statement was the introduction of the Navy Estimates. In ordinary times a full and detailed review is given, especially of the shipbuilding operations; but on this occasion no details could be divulged. The Navy Estimates were made up of token votes, each of 1000*l*., and it was not possible to indicate the extent of the programme either in progress or in prospect. Mr. Balfour, however, lifted the veil to a certain extent by the statement that since the war began the tonnage of fighting ships added to the Fleet was one million, that the *personnel* had been doubled, the increase being from 140,000, without reserves, to 300,000, with a certain early increase to 350,000. He admitted, however, that there had been a reduction in armoured cruisers through losses, intentionally not met by new construction, but contended that in every other type of craft necessary for a Fleet having such multifarious and extensive duties, everything was being done towards the maintenance of the strength of the Fleet. The only limitation, as he pointed out, was in respect of labour. He said that the efficiency of labour could only be increased by getting skilled men from the Front, by dilution, or by inducing men to work to the full limit of their capacity, and in all these respects effort is being made to meet the difficulties.

Mr. Balfour was happy in his reference to the work of the Fleet. One hears occasional murmuring because a ship eludes the patrol, but, as the late Lord Salisbury once counselled the student of politics, in the study of history maps of large scale ought to be used by all who wish to get a sense of proportion. When one reflects on the immensity of the venue of possible active operations, extending from the White Sea, on the Arctic fringe of Russia, to the blue waters of the torrid zone in the Persian Gulf—a length of 5000 miles—and in view also of the great activities of the British and Allied shipping—the extent of damage done by German submarine-boats shrinks into insignificance. About four million combatants have been transported, many of them on very long voyages, one million horses and other animals have been carried, 2½ million tons of stores, in addition to 22 million gallons of oil, have been conveyed, all through routes encompassed by German submarines. The triumph of the Navy in this matter is one to be greatly proud of. Mr. Balfour paid tribute not only to the men of the fighting fleet, but to those who trawl for mines, conduct the auxiliary service, and, most welcome of all, to the sailors engaged in the ordinary oversea commerce of the Empire, who have to face great risks without the means of combating attack.

It was natural that attention should be devoted to the air service. Mr. Balfour, without attempting to enter upon the question of whether the command of the air should be in charge of a separate department, with a Cabinet Minister, as is frequently urged, very properly pointed out that, even if there were such a department, the Navy must have charge of the air wing essential to that service. The number of naval aeroplanes, he stated, had been increased tenfold since August, 1914. Special provision had been made lately for the education of airmen, and a Committee was now organised in connection with the supply of machines. There would still seem to be a sharp difference of opinion as to whether airships or aeroplanes ought to be given constructional priority. Mr. Balfour indicated that it was extremely desirable that we should have "lighter-than-air" machines for naval scouting, but the difficulty with the non-rigid types was associated with the construction of buildings to house them, owing to the present condition of labour. The kite balloon, which also has been handed over by the Army to the Admiralty, has undergone great and growing development and its utility is more widely recognised. Colonel Churchill took exception to what he termed "the attitude of pure passivity" adopted in connection with air defence, and he found some consolation in reflecting that during the time that he and Lord Fisher were at the Admiralty a handful of naval pilots had carried out a vigorous attack on Cologne, Dusseldorf, Friederichshaven, and even Cuxhaven itself. "The great remedy against Zeppelin raids is to destroy the Zeppelins in their sheds," was one of his few dicta approved by the House of Commons.

CORONA ELECTRIC DISCHARGES.

To the young generation of electricians the electrophorus and the frictional electric machine are little more than toys, and hardly familiar toys even. The older generation remembers the large share which these simple apparatus had in helping to build up the foundations of the science of electricity, and they fully enjoy experimental displays such as Principal Silvanus P. Thompson, F.R.S., gave at the Royal Institution last Friday on "Corona and Other Forms of Electric Discharge," in which he largely relied on the physical laboratory outfit of half-a-century ago. The term "corona discharge" had been introduced, he explained, by C. P. Steinmetz, of Schenectady, to indicate the luminous glow noticed all along aerial lines of conductors transmitting electric power at very high pressures. That glow involved a loss which might become considerable. The tendency to leak was proportional to the potential; but if the potential were decreased, the current would have to be increased, if the same power was to be transmitted, and that would mean stouter and more expensive conductors. As regards the form of the electric discharge at high tension, which the lecturer illustrated by means of experiments with the big Wimshurst machine and other apparatus of the Royal Institution, and of a 150,000-volt transformer of Messrs. Siemens Brothers, installed for the lecture by Mr. Alexander Siemens, Faraday had distinguished spark, brush, and glow discharges, the glow being silent and without structure. In the experiments with the transformer the discharge was passed between a point and a disc, between two discs, attached centrally to a plate of glass, between two wires bent as in a lightning-arrester of the horn type (in which the arc-flame travelled upward), and through a piece of wood, as thick as a finger, which sparked all over until it flared up.

The electric pressure of electric power transmission, Dr. Thompson continued, had grown amazingly in the last decade. In 1904 no large power-station of the United States had distributed at more than 10,000 volts; now more than 16 million horse-power were being transmitted there at pressures of over 100,000 volts, up to 160,000 volts indeed. The Los Angeles district had, in 1904, 25 miles of lines transmitting 1600 horse-power; at present 85,000 horse-power were taken over distances of 240 miles at 150,000 volts and 50 cycles by double lines resting on 3388 towers, 43 ft. high, 82 ft. apart and supporting 190,000 insulators of the petticoat, chain and other types. The lecturer showed photographs of other lines, some (transformer stations in particular) irredeemably hideous, others of passable appearance. There were leakage losses and danger of disruptive discharge from all these lines, and the problems of stress distribution were complex, as they were in the analogous mechanical cases on which Professor Coker had lectured the previous week. The tendency to break down depended not so much on the actual potential as upon the potential gradient near a conductor, and the introduction of insulators and the unavoidable asymmetry of the conductors complicated the phenomena very much. The insulation would most easily break down at the tip of a point, and the tables and curves exhibited concerning sparking distances obtained in experiments with points, plates, wires and earth, spheres, &c. (by Steinmetz, de la Rue and Müller, Alexander Siemens, Watson, and others), did not seem to be in good accord, because the conditions varied. According to Steinmetz, the striking distance between needle-points were: 20 kv., 1 in.; 100 kv., 10 in.; 150 kv., 15 in. Expressed in kilovolts per centimetre, the values were: in air, 34 kv. (higher values in thin air films); 49 in oxygen; 34 in nitrogen; 35.5 in carbon dioxide; 28 in hydrogen; 24 in argon, and 4.4 in helium. According to various authorities, the striking potentials through solid dielectrics, again in kilovolts per centimetre, were: paraffin oils, 140 to 125; paraffin wax, 400 to 200; porcelain, 141 to 130; paper at 20 deg. Cent., 180 to 140, at 80 deg., 120 to 110; mica, 850 to 700; micanite, 255 to 225; ebonite, 1414 to 800; glass, 1300 to 200; paper saturated with linseed oil, 552 to 393 kv. per cm. A conductor of high dielectric capacity would concentrate the lines of force in and near it; this property led apparently to paradox effects. Thus the transformer discharge would not pass through the 1 in. of air separating two charged metal plates; but when Dr. Thompson held an ebonite rod between the plates, the discharge passed at once, striking the rod. Round thin wires the air insulation broke down more easily than round stout wires. In order to obtain a uniform potential gradient right through the insulation of a cable Jona had provided cables with four layers of insulation, the innermost layer consisting of pure rubber, the two following layers of less pure rubber, and the outermost of paper.

The lecturer then referred to the electric wind, the apparent air current created by the mutual expulsion of the air particles which were electrified by the escape of electricity from points at high potential. That wind, he said, would not be deflected by a crossing air current, which would deflect another air current, and the sharp point of a conductor, approached to a charged body, would quickly discharge the body by a wind of this kind. Dr. Thompson showed in this connection the electric windmill and the odd behaviour of a bundle of strips of paper, attached to a wire; they diverged when charged, but collapsed when a metal point was approached, but did not disturb themselves, again, when the sharp point was covered with a knob of wax. Finally Dr. Thompson demonstrated how beautiful Lichtenberg figures could be produced. Lichtenberg, a Göttingen professor of physics, also known to wield a clever satirical pen, had accidentally discovered, in 1777, that the dust adhered to positively or negatively electrified spots of a cake of resin, in patches or in peculiar ramifications. Dr. Thompson made use of the orthodox cakes of pitch or resin, and of mixtures of red lead and yellow lycopodium powder; but some of his experiments were novel. He placed, for instance, a little stool of wood, standing on five steel pins, on the cake, and electrified the wood with the aid of a Leyden-jar spark. The points on which the pins had rested were afterwards (when dusted over with the mixture) found to be red patches, each surrounded by a bare ring, and further out by radial yellow veins, the whole suggesting a pattern of butterfly-wing eyes or polarised light phenomena; the patches, Dr. Thompson stated, were characteristic electric wind effects. When a medal or coin was sparked on while lying on a plate of pitch or glass, and the latter was then breathed upon or dusted over, the pattern reappeared. Finally, Dr. Thompson, who was assisted by Mr. B. Able, showed some of the spark photographs of Planté, Lord Armstrong, Mr. Campbell Swinton, and Professor A. W. Porter. Particularly striking among the last-mentioned were the discharges through nitrogen at pressures of up to 16 atmospheres; a peculiar fan-like structure appeared, the bands narrowing down, with negative discharges, as the pressure increased; this was characteristic of free nitrogen, and almost a test for it. Thus, Dr. Thompson concluded, old-fashioned experiments were well able to elucidate problems of modern applications of electricity.

OPTICAL APPARATUS IN WAR.

THE outbreak of hostilities caught us short in suitable optical instruments as in all other munitions of war. The great variety of the calls made on the optician by the conditions of modern warfare were well illustrated in a paper read before the Society of Arts on Wednesday evening last, by Mr. C. R. Darling, A.R.C.Sc.I. Almost the only representative of the optical instruments used by military men 100 years ago is the telescope, though, we believe, the binocular form was then unknown. This pattern has, as is well known, received some remarkable improvements within the past few years. The older Galilean form is, however, still in use. Mr. Darling states that its magnifying power is from 3 to 5, whilst the field of view ranges from 3 deg. up to 4 deg. 30 min. A prismatic binocular, on the other hand, magnifying six to eight times, has a field of view of from 4½ deg. up to 8½ deg., the advantage of which is obvious. The main merit of its older rival is the relative brilliancy of the image. The greater magnifying power and wider field of view are not, however, the only advantages of the prismatic type. Being essentially the same in principle as the astronomical telescope, it can be fitted, like the latter, with the equivalent of a micrometer screen, which is placed in the focus in the eye-piece, and is clearly seen at the same time as the distance view. One form of screen described by Mr. Darling under the name of graticule consists of a number of lines ruled on a glass plate. These lines are spaced out to represent minutes of arc right or left of the line of sight, or equivalent deflections above or below it. These graticules, he states, are of much assistance in determining accurately the position of an object in the field of view, and for estimating its size if the distance be known. In a special form, known as the Zeiss stereo-telescope, the prismatic binocular has hinged tubes, and by opening out these the stereoscopic effect can be increased. One pattern in common use for artillery observing purposes has a magnifying power of 10 diameters, a field of view of 4 deg., and has one eye-piece fitted with a graticule, as described. In still another form, known as the "stereo-telemeter," there is a transparent plate in the focus of the eye-piece of each tube of the binocular. Each plate has engraved on it a series of arrows, which are seen in stereoscopic relief over the landscape viewed, appearing to be at different distances from the eye. The arrows are marked from 90 to 3000 metres, and provided the operator's eyes are alike and his sight keen, the error in the distances estimated will, it is stated, not exceed 1 per cent. at 1000 yards, and 4 per cent. at 5000 yards. The Barr and Stroud instrument, which was also referred to by Mr. Darling, has already been described in detail in ENGINEERING. In the international competition held in America a few years ago it proved infinitely superior to the German instruments. No doubt the latter have since been improved. One pattern, 44½ in. long and weighing 13½ lb., will, Mr. Darling states, enable ranges of 5000 yards to be determined within 2½ per cent., and approximate estimates be made of distances as great as 20,000 yards.

Telescopic gun-sights, he states, have generally a magnification of from 3 to 35 diameters. In some patterns, notably the Ross, this magnification can be varied from 5 to 20 diameters without altering the focus of the instrument. The change is effected by a single movement. The advantage of this arrangement is that the low power and correspondingly large field can be used to find the object, and the higher power is then brought into use to get better definition. The great advantage of telescopic sights is that the fiducial mark and the object aimed at are in focus simultaneously. Searchlights also make severe demands on the skill of the optician. At one time the mirrors were of glass, but they are now always of metal, the reflecting surface being silver or gold, or occasionally palladium or nickel. The mirrors used for lighting up a large area at a short range are, Mr. Darling states, parabolic in vertical section and elliptic in horizontal section. A lateral dispersion of as much as 45 deg. can thus be obtained with a vertical dispersion of a few degrees only. Another plan of attaining the same end is to place cylindrical lenses in the path of the beam. By adjusting the distance between these lenses any desired lateral dispersion can be obtained. This plan is favoured by the Navy, as with it one focus of reflector can be used for all purposes. The largest reflectors are about 4 ft. in diameter, and the smallest 14 in. For the small lamps, taking 20 amperes, the carbons are 18 mm. and 12 mm. respectively; whilst with the large lamps, taking 150 amperes, the carbons measure 38 mm. and 26.5 mm. The management of these lamps requires, Mr. Darling said, considerable skill, but the need has been met by students from our technical colleges.

NOTES.

VACUUM ELECTRIC CIRCUIT-BREAKER.

A FEW years ago C. E. Walsoe introduced an automatic circuit-breaker of the vacuum type for the protection of telegraph and telephone apparatus, which has been adopted in Denmark. The idea is to obtain protection against currents of relatively low tension, because the ordinary protective devices of the type of lightning-arresters do not operate at less than a few thousand volts. Walsoe reduced that tension to about 300 volts for direct currents. But direct currents of the usual 220 volts and alternating currents of 150 volts are of a sufficiently high tension to become dangerous to telephone apparatus, and for such tensions ordinary vacuum-bulbs cannot be relied upon. If the bulb originally contains air, the available variables are the air pressure and the electrode distance; a third variable becomes available by the use of special gases, and in this way F. Schröter claims to

have effected an essential improvement of the vacuum arresters. He charges the bulbs with one of the rare gases or with mixtures of them at low pressures; the apparatus are quite simple. The lower portion of the vertical tube or bulb contains metallic sodium or potassium, or the well-known alloy of these two metals, which is so much utilised; this metal is the cathode, and it must, of course, be introduced into the already evacuated bulb. The anode is formed by an axial wire of aluminium, so suspended in the bulb that its lower end is a few millimetres above the metal. Lest any metallic mirrors be formed in the bulb and give rise to short-circuits, the wire is partly sheathed with a glass tube. Connection with the leads is made through platinum loops, fused into the bulb. When the device is coupled with other sensitive apparatus, a brush discharge will pass in the bulb as soon as the potential exceeds a certain value; an electro-magnet is then excited, and the apparatus are cut out until the tension has sunk to its normal level again. The bulb and its electrodes do not absorb much of the rare gas. A gas mixture of two parts of neon and one part of helium at a total gas pressure of 2 mm. of mercury has been found very suitable and had, according to Schröter's communication in the *Elektrotechnische Zeitschrift*, 1915, page 77, operated thousands of times at the low tension of 104 volts. The article describes various ways in which this vacuum protective device can be connected up. There is not much helium and neon wanted, and these gases are no longer expensive.

THE STRENGTH OF ICE.

Some years ago experiments were started by the late Professor R. S. Tarr in the geological department of Cornell University, New York, on the behaviour of ice under pressure, mainly for the purpose of elucidating the structure and flow of glacial ice. The experiments were continued by J. L. Rich and O. D. von Engeln, and the latter recently published a full account in the *Zeitschrift für Gletscherkunde*, and a somewhat abridged account in the *American Journal of Science* of last November (vol. xl., pages 449 to 473). Compression tests were made on cubes of ice ranging from ½ in. to 2 in. square, and on cylinders of ice 4 in. and more in diameter. The screw presses were especially designed by Professors Kimball and Wells, of the same University, so as to oppose various degrees of resistance up to complete rigidity under the pressure applied, up to 500 lb. per sq. in.; the cylindrical presses were made of lead or copper; details of the presses are not given. It was found that the crushing strength of pond ice was 1000 lb. per sq. in., when all the ice crystals were oriented in the direction of the principal axis, and the pressure was applied in this direction. With pressures at right angles to the principal axis, the crushing strength was about 350 lb. per sq. in.; glacier ice gave intermediate values, mostly nearer the upper limit. These values were hardly affected by temperature, provided the temperature kept well below freezing-point—below 25 deg. Fahr. generally. They are considerably higher than those observed by H. T. Barnes (Transactions of the Royal Society of Canada, 1914, pages 22 to 49); but Barnes experimented with large blocks of river-ice, irregularly oriented, at higher temperatures (sometimes above freezing-point), and he applied his pressures rapidly. When the pressure was rapidly released, Engeln noticed that the ice would crack and break. A slowly-applied (and slowly-released) pressure could be borne for several days, even near crushing strength. Under those conditions ice would flatten out to one-fourth its original thickness, and look perfectly homogeneous and clear, like crystal, showing cracks only near the edges; the air temperature in these experiments ranged from +17 deg. down to −4 deg. Fahr., the apparatus being kept in the outer laboratory. The ice has sufficient elasticity not to undergo permanent deformation until a certain stress is exceeded, and the yield-point is near the crushing strength of the ice. In some cases a core of ice was placed in a cylinder, and the space then all filled with water. The compressed frozen mass proved homogeneously crystallised all through, the crystals extending right across the cylinder and not only radially inward. Ice crystals seem to be made up of thin molecular laminæ lying in planes normal to the principal axis, which glide over one another when the ends of the principal axis are supported. In ice, masses consist of aggregates of crystals, variously oriented, rather than of single crystals, and the physical phenomena are hence those of crystalline aggregates. The phenomena would explain why, in glaciers, the rate of flow seems to decrease from the surface to the bottom, whilst the erosive power is greatest near the rigid colder bottom. In further researches it is proposed to freeze blocks of ice from salt water of different degrees of salinity.

ELECTRIFICATION SCHEMES OF SWEDISH STATE RAILWAYS.

The Swedish Government has decided to ask the State Railway Department to prepare a detailed plan and calculation of costs for the electrification of the Kiruna-Lulea Railway, to ask the Waterfalls Board to prepare plans for a further exploitation of the Porjus Falls, with this electrification in view, and to ask the State Railway Department, jointly with the general staff and the Waterfalls Board, to get out a plan of cost for the continued electrification of the State Railways. The electrification of the Riksgräusen-Kiruna Railway seems to have given altogether satisfactory and encouraging results, even if the costs have somewhat exceeded the calculations. The Waterfalls Board is understood to have the plans for an additional exploitation of the Porjus Falls nearly ready, but the Government, or Royal Majesty, as the official wording is in Sweden, in addition to viewing the electrification of the Kiruna-Lulea or Svartön Railway with decided favour, thinks the time has come to deal with the question of the State Railways on a broader basis. A previously prepared plan by the State Railway Department for railway works up to and including the year 1923 also contains a programme for the electrification of a number of State railways. According to this plan, the sections that ought to be first taken in hand are as follow:—Kiruna-Lulea; Stockholm-Upsala-Krylbo; Stockholm-Gothenburg; Katrineholm-Norrköping; Järna-Nykoping; Malmö-Trelleborg and Gothenburg-Malmö. The cost of the electrification of these lines is calculated at 2,650,000*l.*, which figure, however, only covers the cost of the necessary lines and transformer-stations, but not the cost of power-stations and electric locomotives. This plan will now be overhauled, and the general staff and the Waterfalls Board consulted. With regard to the generation of the vast amount of energy which such a comprehensive scheme of electrification will require, the State power-stations already constructed—Trollhättan, Porjus, and Alfkarleby—will be able to supply important sections, especially when their capacity is further increased, as that of the Porjus power-station will be; but the Stockholm-Gothenburg, the Katrineholm-Norrköping and the Järna-Nyköping line, in addition to the energy which can be derived from the Alfkarleby and the Trolhättan power-stations, will probably require a power-station in the Motala stream. Amongst those falls, which the State purchased some ten years ago for railway electrification purposes, were some valuable and well-positioned waterfalls in the Motala River; plans are being prepared for their exploitation, and negotiations are pending with some private waterfalls owners in the same stream which may lead to the State there obtaining an exceedingly well-situated hydro-electric power-station of considerable capacity, which will prove of great value for Central Sweden. In the Lagan the Swedish Crown owns the Laholm Fall, about 3 metres high, calculated to yield some 3300 horse-power, and the Karse Fall, higher up the river, with a calculated capacity of some 10,000 horse-power. Private enterprise has exploited several privately-owned falls in the same river, and it is part of this latter energy which the South Swedish Electric Company is now exporting to Denmark. It has been suggested that an advantageous co-operation between the projected State power-stations in the Lagan and this company might be arranged, and as plans are being prepared for such State stations, the matter is likely to be proceeded with ere long.

AMERICAN ELECTRIC RAILWAYS.—The electric railway companies of the United States constructed last year 596 miles of new track; this was a decrease of 17 per cent. as compared with the corresponding new construction of 1914. The decrease in new building last year was, however, offset, to some extent, by the electrification of 448½ miles of steam railway, making a total of 1044½ miles of new American electric railway brought into operation in 1915. This showed an increase of about 9 per cent. as compared with 1914.

THE JAPANESE SOCIETY OF NAVAL ARCHITECTS.

ON October 23 last this Society held its autumn meeting, when the following papers were read:—On "The Building-Dock, as in Operation at Kure Naval Dockyard," by Admiral-Constructor Yamada; on "The Breaking of Propeller-Shafts," by Mr. T. Shibata (Marine Bureau of the Department of Communications); on "Tonnage Measurement," by Mr. Yukio Yamamoto (Surveyor to the Marine Department); on "Stress Distribution in a Plate with an Elliptic Hole," by Dr. Y. Yokota, Tokyo Imperial University; on "The Question of Longitudinal Bulkheads, in View of Actual Experiences in the Present War," by Dr. F. P. Purvis, Tokyo Imperial University.

SHIPBUILDING IN DOCKS.

Admiral Yamada's paper is based upon his actual experience of work carried on under his superintendence at Kure. Unfortunately the exigencies of the Service did not allow him to give figures, and his conclusions have therefore to be taken without any data for testing them. He made various assumptions as to whether interest, and what rate of interest, were to be reckoned upon the capital expended on the dock, as to the time occupied by each ship built therein, and as to the number of ships which one set of launching-ways would serve when the ship was built on an ordinary slip, and not in the dock. According to his various assumptions, he found that the capital value would be paid off in from five to eighteen years. Reckoning 8 per cent. as the rate of interest, and that one ship could be constructed in the dock every eighteen months, the capital could be paid off in ten years.

THE BREAKING OF PROPELLER-SHAFTS.

Mr. Shibata's paper dealt with a large number of broken shafts, and investigated the causes of fracture, with special reference to the effect of curvature in the length which might be produced by want of truth in the alignment or by change of form in the ship. He showed that in renewing the stern-tube bearings very great care was needed, and advocated some provision for adjustment in case of want of alignment. In twin-screw vessels he found that the connections of the outside brackets were often too slight, allowing some drop at the after end, which helped to produce the curvature.

JAPANESE TONNAGE MEASUREMENT.

Mr. Yamamoto's paper was chiefly interesting from the Japanese standpoint. It showed that tonnage as it used to be measured by Japanese units, and with Japanese exemptions, was very unfavourable as compared with British tonnage, and added a considerable percentage to both the gross and the net tonnage of any particular ship. Recent legislation, however, had corrected this. He went on to discuss the *pros* and *cons* of other methods of fixing tonnage than the British method; in doing so he travelled over somewhat familiar ground, and found anomalies which could be remedied only by the most practical considerations.

STRESS DISTRIBUTION IN A PLATE.

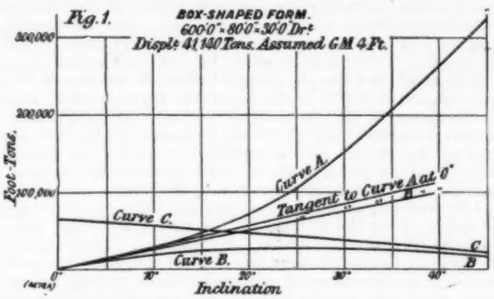
Dr. Yokota's paper returned to his attack on the important subject he has set himself to investigate; we have published details of his earlier work.

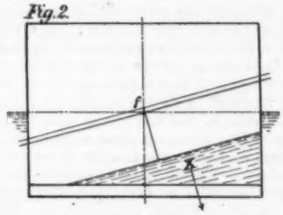
LONGITUDINAL BULKHEADS AND EXPERIENCE DURING THE WAR.

Professor Purvis's paper took (as a pure coincidence) much the same lines as those followed by Professor Hovgaard in his article in ENGINEERING of September 3 last. We reproduce that part of Dr. Purvis's paper which may be regarded as supplementary to Professor Hovgaard's review.

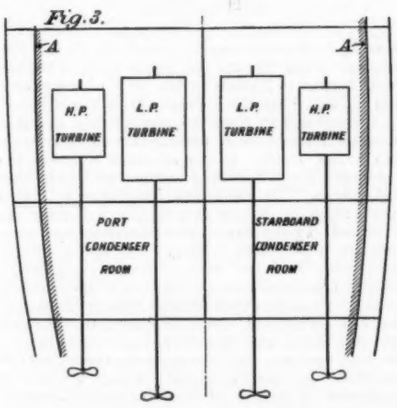
I will avoid the extreme condition of a middle-line bulkhead, and take rather two longitudinal bulkheads, dividing the breadth transversely into three approximately equal portions. To compare with this, I will take also no longitudinal bulkhead, the whole space under consideration being supposed open, from ship's side to ship's side. For present purposes it will, I think, be sufficient to do this for a box shape only; the procedure is necessarily much simpler; it permits ready verification, and the results should be sufficiently approximate to those for a ship to allow of profitable discussion. The conditions I have actually worked out are for a form 600 ft. by 80 ft. by suitable depth; draught, 30 ft.; displacement, 41,140 tons; GM, 4 ft. A length of 120 ft. amidship is supposed flooded, the fore and aft trim being unaffected. A watertight deck at the level of the 30-ft. water-line is also assumed. Free from water, curve A (Fig. 1) shows moments of stability in terms of angle of heel. Taking

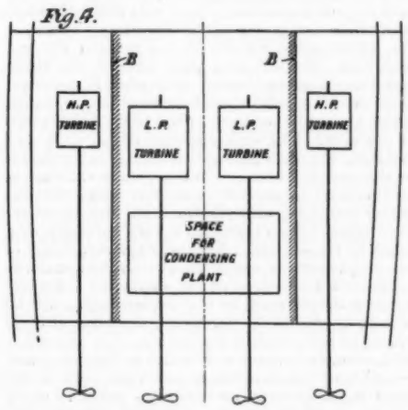
next no longitudinal bulkhead, the effect of water can, as before, be dealt with by considering the upsetting moment of the couple, one force of which is the weight of the water admitted, the other the new zone of buoyancy that balances this weight; the calculation is made simpler, in the case of a box-shaped form, by the fact that the centre of this zone of buoyancy is always situated on the centre plane of the ship. Simple inspection will show that for any angle of heel the maximum effect, measured by moment, is obtained when the vertical through f^* bisects the free water surface; hence for each angle a different amount of water exerts the greatest upsetting moment. Curve B gives the values of these moments in terms of angle; so that difference of ordinate of Curves A and B expresses resultant moment acting on the ship at each angle. Passing now to the case of longitudinal bulkheads fitted over the same length of 120 ft. amidship, I have supposed them to divide the breadth into three

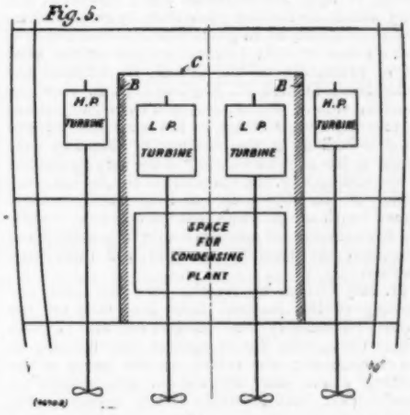




A. Curve of stability for intact condition.
B. Upsetting moment, with 120 ft. flooded; no longitudinal bulkhead; assuming at each angle the water which will give maximum upsetting moment.
C. Upsetting moment, with 120 ft. flooded, between the shell, and a longitudinal bulkhead 27 ft. from the shell.







portions, 27 ft., 26 ft., 27 ft.; the flooding of the outer of these, on one side of the ship, gives a constant weight—2410 tons—on account of the assumed deck at the 30 ft. draught. The increase of draught caused by this weight is 1.76 ft., and following the same method as before, I have taken the moment of the 2410 tons about the centre of the zone of displacement between the draughts 30 ft. and 31.76 ft. Curve C gives the values of these moments in terms of angle; they are upsetting moments, to be compounded with the righting moment of Curve A. The intersection of A and C expresses the angle to which the ship would heel, with the side compartment thus flooded. For my present purpose the comparison of Curves B and C is of outstanding importance; it shows that throughout the whole range of possible heel the case of longitudinal bulkhead is greatly worse than that of no longitudinal bulkhead. This conclusion applies only to the spacing adopted in the above calculation; an interesting addition might be to ascertain at what distance from the ship's side the longitudinal bulkhead would have to be placed in order to make curve C come below curve B at any stipulated angle.

At the last meetings of the Institution of Naval Architects in London Mr. Stromeyer† raised the question whether it was not possible to overcome dangers of the nature I have been dealing with by some arrangement whereby, in the case of a wing compartment being flooded, the corresponding compartment on the opposite side would also be flooded. The channels, he pointed out, would have to be very large, so that the water could equalise itself quickly. Sir Archibald Denny, in friendly criticism, pointed out that the channels Mr. Stromeyer contemplated could not be wasted; cargo or coal must be placed in them, and then they would be in danger of getting choked with coal-dust or in some other way. Both of these gentlemen recognised the value of the time element; Mr. Stromeyer would agree, I am sure, that anything short of free communication between the corresponding compartments on the opposite sides of the ship would make the communication channel useless.

In discussing the questions I have raised I may very properly be asked to state what I would propose as a means of isolating the engine-rooms (1) for twin-screw machinery; (2) for triple-screw machinery; or, again, for avoiding the danger of bunker-bulkheads, such as those in the Lusitania. Such questions would certainly have to be faced; but my present object is the more primary one of trying to decide whether or not longitudinal bulkheads introduce a real danger which must, in any case, be avoided; if that is established, then mechanical genius is quite capable of meeting each difficulty when once it has to be seriously dealt with. In the matter of side bunkers, it is to be noted that whether intentionally made water-tight or not, they retain water, and may be dangerous on that account; the danger, if it exists, can in their case be readily provided against by interruption, at suitable points, of their continuity.

It would obviously be absurd to push anything I have advanced in the above to extremities, however logical the conclusion arrived at. The inner shell of side tanks in merchant ships, and of the equivalent wing space in warships, might be considered to be a longitudinal bulkhead placed at a moderate distance from the ship's side; water entering the spaces undoubtedly causes a list of more or less degree; but generally, at least, the advantages of subdivision vastly override the dangers of this list. Probably there should be some relation between the maximum distance of inner shell and such features of the ship as breadth, GM, &c. Such matters involve details which it is not my present intention to deal with.

Dr. Purvis's paper came up for discussion at an adjourned meeting on December 10. The author then read a postscript drawing attention to Professor Hovgaard's article, and explained further that the volume of the Institution of Naval Architects had come to his hands since he wrote his paper. From it he quoted Sir Archibald Denny:—"We are having a great deal of experience just now of vessels foundering or being sunk; but I have not heard yet in merchant ships, which are usually divided transversely, of any case of capsizing. They seem to go down head first, or stern first, or sink bodily without capsizing." In view of these words it seemed interesting also to note the part Mr. John Reid had taken in discussing Mr. Gatewood's paper at the meeting of the American Society of Naval Architects in December, 1914. Speaking of the loss of the Empress of Ireland, and premising that he had been called upon to investigate that catastrophe, Mr. Reid said:—"To make a long story short, this longitudinal bunker-wall prevented the water from going across the ship, and the Empress heeled from the moment of impact, and went over in 12 minutes, absolutely capsized."

Captain-Constructor Yamamoto, in the discussion following Professor Purvis's paper, suggested that the paper somewhat exaggerated actual conditions, as, in fact, no ships were built with longitudinal bulkheads dividing the spaces into three equal parts.

Captain Engine-Constructor Saito raised some questions as to the best arrangement of bulkheads for a four-screw design, showing that in Fig. 3 as the usual one. He preferred the plan shown in Fig. 4, an arrangement actually adopted in some recent ships; each wing compartment had one of the higher-pressure turbines, and the centre room the two low-pressure turbines and the whole of the condensing plant. The heel produced by water entering a wing compartment in the arrangement Fig. 4 was less than that in the case shown in Fig. 3, and at the same time one shaft only was put out of work, and steam was supplied direct from the boilers to the low-pressure turbine on that side of the ship where the outer compartment was damaged. Continuing, he referred to possible protection of the bulkheads by armour, and advocated that the armour should be placed on the bulkheads BB in the arrangement shown in Fig. 4; since, being farther from the ship's side than AA, thinner armour could be used.

In his reply, Professor Purvis admitted the exaggeration referred to by Captain Yamamoto for the case of two longitudinal bulkheads, but pointed out that the conditions he had assumed underrated the effect of one bulkhead only; his object had been to take roughly a mean condition. For the condition of longitudinal bulkheads placed one-quarter of the breadth from the ship's side instead of one-third, it would be approximately correct to reduce the ordinates of curve C in Fig. 1 in the ratio of 32 : 27 near the zero angle, but not at all near 45 deg. Referring to Captain Saito's remarks, he asked engineers to consider whether they could not allow a transverse bulkhead C (Fig. 5) between the two longitudinal bulkheads marked B in Fig. 4; there would then be a sort of glorified passage, which would overcome the evils under discussion.

In conclusion, Professor Purvis mentioned that two matters had weighed heavily on his mind since the beginning of the present war; both of them, he thought, they, as naval architects, ought to take most seriously to heart, and consider whether lessons of great importance for the future could not be learnt from them. One was the rapidity with which ships, when damaged, were found to sink; and it was with that one aspect of this problem that his paper was intended to deal. The other was the frequency of explosions within a magazine in a warship. Schemes had been propounded by Sir J. H. Biles, Owens, Thurston, and others for better protection of magazines. Professor Purvis thought there was room for consideration of an improved method of stowing the high explosives within the magazines.

* This point f is the centre of the upper surface of the new zone of buoyancy.

† See ENGINEERING, vol. xcix., page 359.

LITERATURE.

De la Portée des Projecteurs de Lumière Électrique. Par JEAN REY, Ingénieur Civil des Mines, Lauréat de l'Institut. Paris: Berger-Levrault, Éditeurs.

IN modern warfare, whether on sea or land, various forms of optical apparatus for concentrating a beam of light on objects at a considerable distance have been largely employed to increase the efficiency of artillery, for night reconnaissance, and, with some modification, for flashing signals when radiotelegraphy is inaccessible. The same device has added to the evil capacity of the rigid dirigible, and at the same time suggested the means of detecting the presence of the sinister visitor. The types of apparatus in use are many, and with the view of increasing their efficiency mirrors and lenses have been largely increased in diameter, more powerful illuminants have been employed, and greater ingenuity displayed in the construction; but there does not seem to have been any exhaustive examination of the most effective assembly of the various parts, or of any accurate determination of the range attainable by the enlarged apparatus. The increase of efficiency with size depends upon the combination of a number of factors whose operation can be decided only by rigorous experiment, and the details of such experiments appear to be few and inadequate. The author's statement that no comprehensive work exists on the theory of the projection of electric light accompanied by measurements of surface intensity is probably correct, and the want of such information may be traceable in some measure to the difficulties of exact photometric measurement. Although the measurement of the intensity of points of light has attracted much attention, it is only within the last few years that any great interest has been displayed in photometric measurement of the amount of light received upon a surface, after being submitted to the effects of diffusion and reflection. Though M. Rey has kept in view the practical side of the inquiry, and has rightly aimed at accuracy and precision, he has occasionally found himself baffled by the number of variables over which he has no control, such as the varying opacity of the atmosphere, the character of the background, colour of the object, &c., and has had to content himself with comparative, and not absolute, results. He has summarised much valuable information and presented the whole in a lucid and interesting manner.

M. Rey divides his treatise into two parts, one treating of the incident light that falls on the mirror, describing the mechanical and optical effects that make for or against the efficiency of the apparatus; the other, of the range of the emitted beam, and the causes, atmospheric or physiological, that interfere with or modify effects of the transmission. The source of light in general consists of an arc lamp, placed as nearly as possible in the principal focus of a reflecting mirror, which may assume various forms. The arrangement of the carbons is a matter of some importance, for it is found that the light received on the mirror emanates almost entirely from the incandescent crater of the positive carbon, the light from the flame and the point of the negative carbon being practically negligible. Hence the diameter of the negative is made much smaller than that of the positive carbon, and the adjustment of the pair is so regulated that the negative shall obscure as small a portion as possible of the positive crater. The negative element may not be indefinitely reduced, because it would wear away so rapidly that constant and troublesome adjustment would be needed. The loss from obscuration has to be balanced against this inconvenience, and any improvement must come from greater care and ingenuity in manufacture. In no case, however, can the entire area of the incandescent crater accurately coincide with the focus of the mirror, nor is it desirable that it should, for it is necessary that the emitted beam or cone of light should have a sensible diameter. With the instruments of short focal length at present in use, at a distance of 1000 metres from the lamp the diameter of the cone will be about 30 metres. Theoretically the diameter is proportional to the distance from the focus, but practically it is found that at a great distance the breadth is less than indicated by theory, and larger when near the apparatus. This is due to the extra focal light which is transmitted, and can be perceived at a short distance, but is gradually extinguished. It is necessary that the beam should have a considerable diameter, so as to permit of the ready recognition of an object of large extent.

In estimating the efficiency of the combination of lamp and mirror, many deductions have to be made. The mirror, as originally designed by M. Mangin, has submitted to very great changes. In the early days it took the form of a spherical concave-convex lens, silvered on the convex surface. The radius of curvature of the reflecting convex surface was longer than that of the refracting concave, making the thickness increase towards the edge. Such a combination possesses evident advantages. With short focal lengths, even of less than seven-tenths the diameter of the lens, the spherical aberration can be made very small, while the chromatic dispersion at the edge is not inconvenient. The use of parabolic reflectors of silver on glass with even shorter focal lengths came into vogue, and through the effect of this competition the Mangin combination was made even shorter; but a limit is imposed by the increasing absorption of light at the edge of the lens, owing to the great thickness of the glass. The weight of the apparatus when the mirror or lens reached 1½ metres in diameter was an obvious disadvantage, and led to the discontinuance of that form. The silver-on-glass mirror has likewise had its day, owing to its fragile character and the risk of injury. The form now most in favour is that of a metallic mirror, usually gilded, and necessarily of a parabolic figure, since only one surface is available. The comparison of the reflective power of solid metallic mirrors with those of glass on which a coating of silver has been chemically deposited is an old problem, and a notably greater efficiency has been assigned to the silver on glass. The author, however, does not agree with this decision; his photometric determinations, which give him results of great consistency, show very little difference in the reflective power of the three forms of mirror. The gilded metal reflects 85 per cent. of the incident light; the silver-on-glass form, if the thickness does not exceed 10 mm., will reflect 87 per cent., while the Mangin lens, of short focal length, owing to the absorption of light at the edge, returns only 83 per cent. The author accepts 85 per cent. as a standard, but the whole of this light is not available for the emitted beam. The negative carbon obstructs a certain amount, protective glass shutters scatter the light at both surfaces, and there are other causes whose influence is very carefully estimated by the author. Naturally the percentage of loss is greatest in the smallest mirrors, and the efficiency of a mirror of 30 cm. diameter, presumed to reflect 85 per cent. of the incident light, will be reduced to 65 or 52 per cent., according to the amount of the attached mechanism. On the other hand, when the mirror is 2 metres in diameter, and is capable of reflecting the same 85 per cent. of the initial light, there is no reduction below 74 or 67 per cent. under the same conditions as in the former case. Under the most favourable circumstances the effective illumination does not increase as the square of the diameter. The author derives an expression in which the exponent 1.72 expresses the increase of practical efficiency.

The amount of illumination concentrated on a distant object will be modified by the focal length of the mirror, the voltage and current in the lamp, and the diameter of the carbons. So far as focal length is concerned, it is shown that the effective illumination increases to a maximum, that is reached when the focal length is 0.664 of the diameter of the mirror; but in the majority of projectors and searchlights the actual focal length is less than that which indicates a maximum of intensity. With the focal length increased from one-third to two-fifths of the diameter, the increase in intensity is about 45 per cent. The fluctuations of light due to variations in the voltage are considerable, as is well known, in the case of carbon-filament incandescent lamps, and in the arc light it is specially difficult to secure ideal constancy. Few details of the method employed by the author are given, but generally it appears that high voltage increases both the intensity of the light and the diameter of the illuminating cone. Intimately connected with the voltage is the diameter of the carbons, and it is difficult to separate the two effects on the resultant beam. As a matter of practical interest and economy, the author shows that if, as is usual, the positive carbon has a diameter of 30 mm., and the negative about half that amount, a current of 100 amperes is too feeble for the most effective work; or if such current only is available, it is desirable to reduce the size of the carbons. Practical considerations, however, limit their size, because diminishing the diameter of these reduces the dimensions of the incandescent crater, whose area varies as the square root of the product of the diameter of the positive carbon by the intensity of the current, and the smaller this value the smaller is the radius of the cone of emitted light, which, if reduction is pushed too far, may become too small to be of practical use.

In the second portion of the volume, M. Rey considers the factors which affect the utilisation of the luminous beam created by the apparatus described in the first part. Prominent among these are the transparency of the atmosphere, the distance of the object with its dimensions and nature, including its colour and that of the background upon which it is projected. The transparency of the atmosphere is a vague term, that cannot be accurately treated by any arithmetical formula, and the physiological effects of colour and diffusion equally elude rigorous mathematical analysis. M. Rey, in order to meet some of the difficulty, has discussed all the information available from experiments, and constructed a table which for typical objects, such as forts and troops, villages and vessels, gives practically the minimum illumination by which these objects can be seen and recognised by the naked eye, or with a telescope having a power of five or six diameters. These values are called *éclairements équivalents*, and his problem becomes the determination of the optical power and equipment that will produce such illumination at a given distance. The method is quite legitimate, and apparently worked out with accuracy. It is an attempt to simplify a formula, due to M. Blondel, which may be written:—

$$E_0 = E_p \frac{a^{l+l'}}{l^2} j,$$

where E_0 is the *éclairement équivalent*, E_p the illumination given by the projector upon a surface placed normal to its axis at the unit of distance—1 km.; l and l' are the distances from the object to the apparatus and observer respectively, and a is the extinction of light in passing through a stratum of air 1 km. thick. If the observer operates the instrument, $l' = l$ and the formula becomes a little more simple. The coefficient j includes all those uncertainties of which the author has tried to rid himself by the device of equivalents, and consequently is put equal to unity. To make a unity would mean that the atmosphere is regarded as perfectly translucent—a course that is undesirable. The author makes a very serious attempt to determine the opacity of the atmosphere in different parts of Europe, and at different elevations above both land and sea, and incorporates the necessary corrections in the equation, which is solved graphically by means of ingeniously constructed diagrams. With the argument E_0/E_p and a given value of a, it is possible to read off at sight the distance at which a particular illumination will be attained; or, given the range, show what must be the strength of the luminous beam that it is necessary to send out in order to detect a typical object. The measure of atmospheric opacity is not the amount of fog or impurity in the air, but the probability that an object will be seen on a greater or less number of days in the year. If an object can be seen in Central Europe on 10 per cent. of the days, it is assumed that the atmosphere will not stop more than 0.041 of the luminous flux in passing through a stratum of 1 km. in thickness, while to be seen on 90 per cent. of the days the object must be so conspicuous that one-third of the light may be absorbed. Such values are not very satisfactory, and in all cases where averages are employed the result of the application to a particular case is apt to be disappointing. But the examples to which the principles are applied are interesting and instructive. For instance, if it is a question of the visibility of a fort at a known distance, standing against a sombre background, the diagrams and theory decide not only whether the object will be visible with certain apparatus, but what diameter of mirror and focal length will be necessary to make that fort visible with known factors of atmospheric absorption. They enable one to see clearly what is the kind of relation between transparency of atmosphere and power of the instrument, and how the problem is affected by change of position of the instrument and of the observer, thus supplying the artilleryman with information that cannot but be useful. He can see

at once whether his instrument is hopelessly inadequate for the task imposed, and the means by which the range may be increased. Again, if a troop of infantry, for example, be visible with a certain emitted light, it is possible to infer the distance of the troop within limits, when the darkness may prevent the use of instruments of a telemeter pattern. In practice, such problems are apt to find a rough solution by long experience, but M. Rey has given greater precision to such inquiries and provided the means for pursuing many important problems to a successful issue.

BOOKS RECEIVED.

Sell's Directory of Registered Telegraphic Addresses, with Telephone Numbers; 1916. By HENRY SELL. London: Business Directories, Limited, 166, Fleet-street. [Price 25s.]

The Newspaper Press Directory and Advertisers' Guide. 1916. London: C. Mitchell and Co., Limited. [Price 2s.]

Magnetic and Other Properties of Iron-Silicon Alloys Melted in Vacuo. By TYRGOR D. YENSEN, Urbana, U.S.A.: Published by the University of Illinois; London: Chapman and Hall, Limited. [Price 35 cents.]

Elementary Applied Mechanics. By T. ALEXANDER, C.E., M. Inst. C.E.I., and A. W. THOMSON, D.Sc. London: Macmillan and Co., Limited. [Price 15s. net.]

Laxton's Builders' Price-Book for 1916. Containing about 73,000 Prices. Originally compiled by WILLIAM LAXTON. Ninety-ninth edition. London: Kelly's Directories, Limited, 182, High Holborn. [Price 4s.]

Elements of Railroad Track and Construction. By WINTER L. WILSON. Second Edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10s. 6d. net.]

Catalysis and its Industrial Applications. By E. JOBLING, A.R.C. Sc., B.Sc. F.C.S. London: J. and A. Churchill. [Price 2s. 6d. net.]

Bridge Foundations. By W. BURNSIDE. 32 Diagrams. London: Scott, Greenwood and Son, 8, Broadway, Ludgate, E.C. [Price 4s. net.]

United States Department of Commerce. Coast and Geodetic Survey. Triangulation in Alabama and Mississippi. By WALTER F. REYNOLDS. Special Publication, No. 24. Washington: Government Printing Office.

United States Department of Labour. Bureau of Labour Statistics. Bulletins. Whole Number, 177. *Wages and Hours of Labour in the Hosiery and Underwear Industry*, 1907 to 1914. Whole Number, 178. *Wages and Hours of Labour in the Boot and Shoe Industry*, 1907 to 1914. Washington: Government Printing Office.

Tacheometer Surveying; with Special Notes on Plotting, Care and Adjustment of Instruments, Field Work, and Calculations. By M. E. YORKE ELIOT, Assoc. M. Inst. C.E. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 5s. net.]

Navigation Notes and Examples. By Naval Instructor S. F. CARD, B.A., R.N. London: Edward Arnold. [Price 8s. 6d. net.]

Elements of Heat-Power Engineering. By C. F. HIRSHFIELD, M.M.E., and WILLIAM N. BARNARD, M.E. Second Edition, Revised. New York: John Wiley and Sons (Inc.); London: Chapman and Hall, Limited. [Price 21s. net.]

Machine Design. By ALBERT W. SMITH and GUIDO H. MARX. Fourth Edition, Revised and Enlarged. New York: John Wiley and Sons (Inc.); London: Chapman and Hall, Limited. [Price 12s. 6d. net.]

UTILISATION OF HAMMER EXHAUST STEAM. — The Rockford Drop Forge Company, Rockford, Ill., says the *Iron Age*, is putting down a 300-kw. Westinghouse low-pressure turbo-generator set to operate on exhaust steam from the hammers in the forge-shop. The hammers number seventeen, ranging from 800 lb. to 4000 lb. The exhaust steam is collected in a 10-in. overhead main, and the distance to the turbine-station approximates 125 ft. The steam is used at a pressure of 2 lb. at the turbine, and connection is made with the live-steam main through a reducing-pressure regulator, so that inadequacy of exhaust steam at any time is compensated for automatically. Hitherto the exhaust has only been utilised for shop and feed-water heating, the greater proportion having been wasted. With the new turbo-generator unit a saving of 1000 dols. per month is figured.

INDIAN COAL-MINING.—The production of coal in British India in the ten years ending with 1914, inclusive, was as follows:—

Year.	Tons.	Year.	Tons.
1905.. ..	8,417,739	1910.. ..	12,047,413
1906.. ..	9,783,250	1911.. ..	12,715,534
1907.. ..	11,147,339	1912.. ..	14,706,539
1908.. ..	12,709,636	1913.. ..	16,208,909
1909.. ..	11,870,064	1914.. ..	16,464,263

The greatest production in any one part of India was effected in 1914 in Bihar and Orissa, which had an output between them of 10,661,062 tons. It is satisfactory to note that the output all but doubled during the ten years. The East Indian, the Great Indian Peninsular, and some of the other leading Indian railways, have had an increased coal traffic in the last few months, there having been a tendency to move larger quantities of coal by railway in consequence of the interruption of shipping facilities by reason of the great war. The value of the coal mined in British India increased from 1,419,443*l.* in 1905 to 3,967,380*l.* in 1914.

SPEED-REDUCING GEAR FOR TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Owing to the fact that Mr. J. H. MacAlpine is at present in America, and will not therefore be able to comment on your editorial of March 3 for some time, perhaps you will be good enough to permit me to draw your attention to the fact that you have omitted to point out the principal feature which places the Melvin-MacAlpine gear in a class by itself.

You state that "Sir Charles Parsons has solved the problem by abolishing the periodic errors. From Mr. MacAlpine's remarks it would seem that the floating frame has proved an equally effective solution." Sir Charles Parsons, by his progressive system of cutting teeth, undoubtedly improved the running of his gears; but even if the gears were absolutely perfectly cut, it would not touch the main problem in connection with turbine reduction gears. When one comes to deal with pinions in the neighbourhood of 5 ft. long by 8 in. in diameter, it becomes of the utmost importance that the alignment of the pinion should be absolutely parallel with the gear-wheel.

Mr. MacAlpine, who is one of our foremost mathematical engineers, has proved that even a few thousandths of an inch makes a serious difference in the strength of the gears. With the floating frame it is impossible that the pinion should ever be out of line with the gear, even after long use and wear, and in spite of strains due to heat and ship movement. Due to this fact alone, Mr. MacAlpine is enabled to use power factors quite impossible to Sir Charles Parsons.

There is also an impression, even in the minds of eminent engineers, that want of alignment is neutralised by the use of helical teeth, allowing the pinion to slide endways, and so adjust itself. A moment's consideration, however, will show that this has no effect whatever, and that no greater length of the pinion is under load than if the teeth were ordinary spur teeth cut parallel to the axis. In short, the MacAlpine system is quieter, has a higher factor of safety, and is much more compact and lighter than is possible with rigid gears.

Yours truly,

Hayfield, Paisley. ALLAN COATS.

"CANALS AND THE COST OF CARRIAGE PROBLEM."

TO THE EDITOR OF ENGINEERING.

SIR,—I must thank you for kindly finding room for my letter of the 28th ult., in reply to criticisms in yours of the 25th on the above subject, and hope that you will permit me again to trespass upon your space in reply to the editorial note to my letter.

First, you have slightly misrepresented me—not intentionally, I am sure—where you state that when I first began to work at the agitation for the reconstruction of our system of inland waterways I stated that our physical difficulties were not greater than on the Continent. I have never said this. I admit that, on the average, there is a greater rise and fall to be overcome in England on routes likely to develop inland water transit than on the Continent. What I did say was that most, if not all, of the results achieved abroad could be obtained here. To secure this I look, to a large extent, to the adoption of modern engineering facilities, and to the skilled assistance of the profession to whose interests your paper is devoted. With their abilities available, I cannot admit that what has been done on the Continent cannot be done here, although possibly at a slightly increased cost.

Consequently I cannot agree with your statement that whatever we spend, we cannot come up to Continental levels of efficiency and speed. On the contrary, I think we may readily beat them. Efficiency in canal transport depends, to a large extent, upon a proper recognition of the relationship between the immersed cross-section of the boat and the cross-section of the waterway, a point which was quite overlooked in France and Belgium in the earlier days of their waterway reconstruction. The relationship with them did not exceed 3 to 1, the 100-ton standard proposed by the Royal Commission is 5 to 1, the standard adopted in France in their very recently designed canals, so that in our scheme of reconstruction we can begin where they leave off, and shall commence with a speed of travel between locks 50 per cent. greater than the speed to which they have hitherto been limited. As a matter of fact, the rate of travel on those canals known as "the Cross," referred to in the Report of the Royal Commission—that is, connecting the Severn with the Humber and the Thames with the Mersey—will be better, and the canals more economical to work upon, than any of the canals upon which the success of water transport in France and Belgium was established.

Even granting your contention that we cannot look for so cheap a transport by water here as in France and Belgium, it is obvious that we can at least do a good deal to reduce the present charges. To-day traffic is being carried by water between Birmingham and London and Birmingham and Bristol at rates slighter lower than are offered by rail; but under what conditions? Between Birmingham and London there are now 160 locks, to be reduced under the reconstruction scheme, as mentioned in my previous letter, to thirty-one locks and fifteen lifts. On the route Birmingham to the Bristol Channel sixty-two locks, to be reduced to ten locks and seven lifts. With such reductions in locks and the larger waterway, enormous economies will be possible, both in labour employed and speed.

As an instance of the first, upon express boats now running to London, with double shifts of men, so as to run night and day, one man is now required to every 7 tons of traffic moved. Upon the reconstructed canal, with 100-ton barges running in trains of three, each man will be responsible for 35 tons.

On the Birmingham to Bristol Channel route—Worcester to Birmingham—with slow traffic—that is, lying up at night—at present one hand is required to every 15 tons of traffic, whilst with the reconstructed canal it will be possible to run through Bristol or Cardiff to Birmingham, with 100-ton boats, with 46 tons to each man on board.

As to time, the trip Bristol to Birmingham now takes 72 hours; conducted on lines which, I am sure you will agree, offer much scope for improvement. A lighter leaves Bristol with, say, 200 tons an board, towed by a tug which may, or may not, carry cargo. If it does not, it returns from Sharpness, handing the lighter over to a canal tug. If it does carry cargo, the two proceed as far as Gloucester. Here the traffic is transhipped into 30-ton barges, towed to Worcester by another tug. At Worcester the small canal is reached, and the traffic is taken on by horses to Tardebigge Tunnel. Through this the barges are towed in trains and on to Birmingham—one transhipment and four or five methods of haulage, with accompanying delays. On the reconstructed routes this trip could be reduced to 36 hours.

These figures amply justify the claims which the Waterways Association put forward for a reconstructed system of inland water transport—a saving in time of 40 per cent., and 25 per cent. in cost.

Yours faithfully,

FRANK IMPEY,
Secretary, the Waterways Association.

37, Newhall-street, Birmingham, March 8, 1916.

THE RHONE BRIDGE AND THE OPTICAL DETERMINATION OF STRESS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the issue for February 25 of your interesting journal, on page 190, I find a statement which requires correction. Underneath the view of the reinforced-concrete bridge at La Balme and in the subject-matter you say that this bridge was "designed by M. Mesnager, Paris." As you will see from the pamphlet which I am now sending you, I did not design this bridge. I did not carry out the drawings nor did I determine the dimensions, this having been in charge of other engineers. But I caused to be made a glass model of the bridge in question, with a view to determine the distribution of stresses in the structure and to verify that calculations previously made approached sufficiently close to the truth, so that the bridge might safely be built, with the assurance that when built it would certainly stand. This bridge required to be approved by the Chief Local Roads Committee, and this Committee delayed in giving its approval in the fear that errors might have crept into the extremely intricate calculations; it was not convinced, moreover, that the hypotheses on which these were based were wholly reliable. The Committee gave its approval to the work after calling at my laboratory and ascertaining the manner in which the measurements had been effected and the facility with which the actual stresses in the arc were obtained. In short, I simply carried out a check which showed the possibility of building the bridge. The calculations were made under the supervision of M. Rabut, Inspector-General of Roads and Bridges.

Yours faithfully,

MESNAGER.

THE MIDVALE STEEL AND ORDNANCE COMPANY.—The acquisition of the Cambria Steel Company by the Midvale Steel and Ordnance Company, says the *Iron Trade Review*, Cleveland, Ohio, will make the latter by far the largest independent steel company in the United States. It will have an estimated annual output of about 1,715,000 tons of pig-iron, about 2,350,000 tons of steel ingots, and 1,900,000 tons of finished products. The Cambria plants will add to the Midvale Company eight blast-furnaces, twenty-six open-hearth furnaces, four Bessemer converters, bar, structural, shape, plate, rail and wire-mills, car-building and axle plants, steamship lines on the Great Lakes, and extensive iron-ore properties on the Lake Superior ranges.

BORDEAUX.—Bordeaux commenced 1914 under favourable auspices. The outbreak of war, however, occasioned a complete change, ever increasing difficulties being experienced in carrying on seaborne traffic with neutral countries, while freights showed a great advance, there being a scarcity of available shipping, to say nothing of financial depression in the Argentine Republic, Brazil, Uruguay, Mexico, and Chili. The imports of coal into Bordeaux in 1914 were 1,561,478 tons; of patent fuel, 72,902 tons; and of coke, 6548 tons. Of the coal imported 1,511,962 tons came from the United Kingdom; of the patent fuel, 20,111 tons; and of the coke, 113 tons. Germany supplied 49,516 tons of coal, 52,791 tons of patent fuel, and 6435 tons of coke. The coal imports from the United Kingdom showed a decrease of upwards of 100,000 tons in 1914 as compared with 1913. In consequence of the dislocation of commerce and finance occasioned by the war, the works on the junction of the Bordeaux Railways had to be suspended; these works, when completed, will connect the Southern of France Railway with the docks, as well as with the port of Pauillac. Four cranes, to be worked by electric power, have been brought into use—three at floating dock No. 2 and one at the Quai de Queyries. During low tides and under the worst conditions steamers drawing up to 23 ft. of water can come to Bordeaux by arriving at high water. During spring tides, under the best conditions, steamers drawing up to 29 ft. 6 in. of water can proceed up the river, and during normal tides vessels drawing as much as 26 ft. 3 in. Iron ore was imported from Spain in 1914 to the amount of 81,000 tons as compared with 72,174 tons in 1913.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, February 23.

THERE is scarcely any change on the market; the underlying conditions heretofore reported continue. Several mills are endeavouring to preserve as much capacity as possible, to sell later on; the pressure is very strong for the deliveries of supplies of iron and steel with as late delivery as the mills are willing to name; over 100,000 tons of steel plates are wanted and but a small percentage is liable to be placed at this time. Orders for munitions and munition material continue to crowd in; one order for 60,000 tons of barbed wire is reported as placed for France. The sale of 12,000 tons of steel rails was made for Africa. Among pending orders are several for 60,000 tons of rails, 30,000 tons of axles and wheels, and 14,000 tons of track-fasteners for export to Russia. Pig-iron is moving up again, and Southern furnaces are making large sales. The embargo on freight into New England has been partially raised. Foundries and engineering plants in that section of the country in some cases ran out of pig-iron. Prices in all kinds of finished material have hardened this week.

It is a matter of surprise that a runaway market does not develop; to all appearances the pronounced shortage of crude iron especially will be manifest. Capacity of all kinds is being handled to give the largest possible output. The New York Central Railroad is in the market for 150 locomotives, and the American Locomotive Company naturally will secure the bulk of the order. The New Haven Railroad will want 50 locomotives. The Chicago and North-Western Railroad is in the market for 90 engines. European countries are endeavouring to secure the acceptance of orders for 500,000 tons of steel bars. In fact, the requirements are so far beyond all capacity. Prices are held down within reasonable limits.

ROYAL CORPS OF NAVAL CONSTRUCTORS.—The examination usually held in June at the Royal Navy College, Greenwich, for the entry of probationary assistant constructors from outside His Majesty's Service and private students of naval architecture will not take place this year.

THE LATE MR. CHARLES RAMSDEN MAY.—We regret to have to announce the death, which occurred on Friday, the 3rd inst., at Bexhill-on-Sea, of Mr. Charles Ramsden May, of Erith, Kent. Mr. May, was a member of the Institution of Civil Engineers. He was born in June, 1859, and served a pupilage from 1876 to 1881 with Messrs. Easton and Anderson. Later in life he devoted much of his civil engineering activity to the service of the same firm, being their outdoor manager from 1893 to 1899. In 1899 he acted as assistant resident engineer for the Assouan Dam, being subsequently appointed resident engineer.

ELECTRICALLY-HEATED SOAKING-PITS.—Electrically-heated soaking-pits for ingots, in place of the fuel-fired ones, are attracting interest in the steel world, says the *Iron Age*. Our contemporary gives a few figures concerning the electric soaking-pits invented by Mr. T. F. Baily, President of the Electric Furnace Company, Alliance, Ohio, and adds that these can compete with gas-fired pits even where moderately hot stripping and charging is practised. The electric pit further has the advantage of a non-oxidising atmosphere, which means a saving of from 1 to 2 per cent. of the weight of ingots put through the pit. It also takes only one-third the space occupied by a gas-fired pit of the same capacity. A feature of still greater importance is the elimination of surface defects in the ingots.

PERSONAL.—Mr. Edgar J. Richards intimates that he has opened an office at 90, Mitchell-street, Glasgow.—Mr. W. H. Patchell announces his change of address from Caxton House to 64, Victoria-street, Westminster, S.W.—It is announced by the Scherzer Rolling-Lift Bridge Company that, following the death of Mr. Albert H. Scherzer, president, the entire stock of the company has been purchased by a syndicate of officials of the company, who have been connected with the business from its inception, and that there will be no change in the *personnel* of the organisation, Mr. Scherzer having taken no active part in the affairs of the company for several years. The Scherzer Rolling-Lift Bridge Company has general offices in the Monadnock Block, Chicago, and an Eastern office at 220, Broadway, New York, with sales connections in various cities in the United States and Europe.

AMERICAN SHIPBUILDING.—The number of vessels now in course of construction in American shipyards for the American Government, as well as for foreign administrations, is returned at fifty-nine. The building firms concerned are the New York Shipbuilding Company, the Newport News Shipbuilding and Dry Dock Company, the Fore River Shipbuilding Corporation, the William Cramp and Sons Ship and Engine Building Company, the Bath Iron Works, the Craig Shipbuilding Company, the Manitowoc Shipbuilding and Dry Docks Company, the Seattle Construction and Dry Dock Company, and the Lake Torpedo-Boat Company. The list of vessels now building includes 30 submarines for various Powers. Further large contracts are stated to be pending. The Shooter's Island yard, Newark Bay, New Jersey, is stated to have been purchased by the Standard Shipbuilding Company. The old Roach yard at Chester, Pennsylvania, has been purchased by the Chester Shipbuilding Company.

THE POSITION OF THE IRON INDUSTRY IN GERMANY.

THE large Phœnix Company has published the results of the first half (July to December, 1915) of the current financial year, and the result is generally pronounced as very satisfactory. The profits are more than double those of the corresponding period of 1914, between two and three million marks in excess of the corresponding figure for 1913, and only 1,000,000 marks short of the corresponding figure for 1912, when markets were very favourable. The gross profits, less general expenses and interest, but with no writings-off, for the first half of the last four financial years were as under:—

	Marks.
First half, 1915-16	21,651,395
,, 1914-15	10,587,390
,, 1913-14	18,849,945
,, 1912-13	22,636,121

The profits for the first half of the current year also compare favourably with that of the preceding half-year, which amounted to 17,498,520 marks, the progressive scale showing that the company more and more has been able to adapt itself to the altered conditions created by the war. This result, apart from the effect of the market, is, to a considerable extent, owing to the increased production both of the mines and the iron works. The production during the first half of the current financial year amounted to 74 per cent. of the normal, so far as the mines were concerned, and 73 per cent. of the normal for the iron works, as against 60 and 65 per cent. respectively, as an average of the preceding war period. Apart from the increased production, the repeated increases in the prices for the company's chief products have their share in the favourable result.

The report states that the aggregate of orders in hand at the iron works on February 1, 1916, amounted to 348,931 tons, against 372,411 tons in the preceding year, and must be considered sufficient with the reduced working.

Reports from the important West German iron and mining district state that 1916 has again brought a general rise in prices, the second half of 1915 having witnessed a break in the repeated increase of prices earlier in the year, and even in a material reduction in some quotations, especially for bar iron. The continued strong demand for war material of all descriptions gave the iron market a support, so that both consumers and the trade were obliged to abandon their cautious attitude, and in sympathy with the lively demand an active business soon set in. An additional reason for the suddenly increased demand is no doubt to be found in the fact that, with the formation of several export unions for rolled products, the inland unions came more to the front, although not to such a degree as many had hoped. It is not the large raw-material combines which have given the impetus to the rise in price. These—first the Coal Syndicate, then the Steel Union, and last the Pig-Iron Union—have only followed in the wake of the rises in price of the unions for finished iron; of these latter, the Heavy-Plate Union, immediately after its new formation, raised the selling price 10 marks per ton, which rise has since been followed by a second of the same amount. The price of rolled wire, which also was raised 10 marks per ton, has in the meantime undergone no further rise, whereas the quotations for wire manufactures, hoop iron, malleable iron, and tubes have. Also bar-steel prices, which at one time had dropped 10 to 20 marks per ton below the minimum price, are again moving upwards. Not only has the former minimum price of 140 marks per ton again been reached, but it has in many cases been materially improved upon.

The present firm tone of the iron market bids fair to continue for some considerable time, for not only are the works fully employed for the first, but also for the second, quarter of the present year. The urgent demand for quality material, principally for military purposes, has virtually never subsided, and now there seems no difficulty in the way of manufacture of ordinary commercial articles, although any material increase in the production with the present labour and working conditions cannot be expected. The lively demand from neutral countries has not been affected by the higher export prices resulting from the formation of the export unions. Neighbouring countries, on account of the complete cessation of Belgian supplies, have to depend almost solely upon Germany, and must therefore put up with the higher prices. The foreign demand has even increased of late, in anticipation of a further rise in prices.

As regards the position within the different branches of the Rhenish-Westphalian mining and iron industry, the despatch of raw products, which for some time was seriously impeded by dearth of rolling-stock, has again expanded. The firm tone of the ore market continues. The Siegerland mines cannot fully satisfy the demand, because it is impossible to increase the production for lack of a sufficient number of skilled hands. The prices for Siegerland ores remain unaltered at 15 marks for raw, and 24.50 marks for roasted ore. Nassau red-iron ore, which is barely obtainable, costs 21 to 23 marks; 30 per cent Minette, 3 to 3.20 marks; 32 per cent., 3.50 marks per ton. Pig-iron, at its raised prices, continues in increasing demand. The quantity despatched by the Pig-Iron Union of quality iron has also increased from 53.65 per cent. of the allotment in December, 1915, to 59.65 per cent. in January, 1916.

Nor is there a bad sale of Luxemburg pig-iron, the selling price of which remains unaltered until April 1 at 74.50 marks, but which will be raised for the second quarter. Scrap iron is firm, vendors holding back in expectation of higher prices. There is no actual scarcity of scrap, but the large supplies from the hostile districts occupied by the Germans have stopped, and material deliveries of scrap to Germany's allies are expected, Austria especially having already acquired a considerable quantity of scrap from Germany.

In half-finished goods the increase in the quantities despatched continues. The works are at present fully employed within the scope of their reduced capacity, and orders come in freely. Business at the increased prices, which have now reached the highest level since the formation of the Steel Union, has already commenced in a satisfactory manner. The demand for heavy railway material gives no cause for complaint, and the works are fully employed; also the demand for light rails has improved. The price for girders has also been raised 10 marks, and now stands at 140 marks delivered at Diedenhafen. In spite of the stagnation in the building trades, there has been some increase in the quantities despatched on account of the activity prevailing in the construction and wagon factories. From abroad the demand for shape-iron continues.

As already mentioned, the prices for bar steel show a rising tendency. Ordinary Thomas bar-steel can only be obtained at 142.50 marks for large orders, otherwise the works demand and obtain 145 to 150 marks. For export, the price for bar steel is about 200 marks per ton. The former price-cutting has entirely ceased, and the works have so many orders on hand that they are fully employed for the first half of the current year. Still stronger is the demand for quality bar iron for military purposes, for which, also, materially higher prices are obtained. The raised prices for malleable iron, which is also in strong demand, stand at 168 marks for ordinary kinds, 185 marks for horse-shoe iron, 200 marks for rivet iron, and 205 marks for chain iron. Outsiders are still offering hoop iron below the price of 180 marks, fixed by the Hoop-Iron Union.

The market for plate iron is very firm, the works are fully employed and hold out for extended time of delivery for new orders. After the latest rise in prices of the Heavy-Plates Union the prices for ordinary heavy plates are 175 marks; for construction plates, 180 marks; for boiler-plates, 180 marks; and for ship's plates, 180 to 185 marks. For exports *via* Holland a price of 125 gulden for heavy plates and 125 to 130 gulden for ship's plates is demanded. The inland price for thin plates has further risen to 200 to 220 marks; the demand for these goods continues so urgent that the works are unable to execute all orders. For export materially higher prices are asked for thin plates, and payment in foreign money is demanded. In pipes business is brisk at the raised prices, especially for gas-pipes, and there is also a good demand from abroad. The prices for wire products have again stiffened, whilst the price for rolled wire remains unaltered at 150 to 160 marks for Siemens-Martin material, since the first increase. The base price for drawn wire now stands at 190 marks; galvanised wire costs 235 marks; barbed wire, 302.50 marks; nail wire, 187.50 marks; and wire nails, 200 marks. With the exception of wire nails, which suffer from the stagnation in the building industry, there is an exceedingly lively demand for all kinds of wire products, more especially for thin wires, and of these, again, particularly for galvanised wire of 1 mm. diameter, which in many instances is used instead of copper wire.

THE PORT OF HAVRE.—The French Government desire it to be known that the Port of Havre is much congested, and it is consequently desirable that British exporters of goods for Switzerland should, in their own interests, send as little as possible by this route for the present; meantime efforts are being made to relieve the congestion.

STANDARD ACCUMULATORS FOR ELECTRIC VEHICLES.—Some little time ago the Electrical Vehicle Committee asked the Accumulator Manufacturers' Section of the British Electrical and Allied Manufacturers' Association to consider the possibility of the further standardisation of lead-acid accumulators for electric vehicles, particularly with regard to rating and over-all dimensions of cells. At a recent meeting of the Committee a communication from the manufacturers was considered, stating that they were prepared to agree to the standard sizes and ratings given below, which the Committee consider to meet present requirements. These and other matters in connection with lead-acid accumulators that have been standardised with the co-operation of the manufacturers will be known as "E.V.C." standards, but it is hoped that they will eventually be adopted by the Engineering Standards Committee as British standards. The E.V.C. standard rating is to be the capacity in ampere-hours obtained by a continuous discharge at a uniform rate for a period of five hours until the voltage of the cell falls to 1.7. For example, if a cell is specified to have an E.V.C. standard rating of 180 ampere-hours, the voltage will not fall below 1.7 volts after five hours' continuous discharge at 36 amperes. E.V.C. standard plates are to be $8\frac{5}{8}$ in. high, $5\frac{3}{8}$ in. wide, and the distance between centres of lugs $4\frac{3}{8}$ in. The over-all dimensions of cells will be $14\frac{1}{4}$ in. high (including connector), $6\frac{1}{16}$ in. wide, and $2\frac{1}{16}$ in. long. The latter figure is for the smallest size of cell, having seven plates; for each additional pair of plates an increase in length of $\frac{5}{8}$ in. is allowed. An exception is made in this dimension in the case of the "Ironclad-Exide" cells made by the Chloride Accumulator Company. In this cell, the length of the seven-plate size is $2\frac{3}{4}$ in., and $\frac{5}{8}$ in. in addition is allowed for each extra pair of plates. The standard inspection-plug will be that which will fit a hole, 1 in. in diameter, in the cover of the cell, and the standard charging voltage will be that suitable for charging forty-four lead-acid cells in series—*i.e.*, from 85 to 120 volts.

RAILWAY CONSTRUCTION AND ELECTRIFICATION.

THE London and North-Western Railway Company has completed certain alterations at Euston, a new booking-hall having been built, extending along the front of the station and facing the courtyard. The section of a new line between Queen's Park and Willesden was opened for traffic in the course of last year; upon the opening of this line, the London Electric Railway service of trains running from Waterloo to Queen's Park *via* Charing Cross, Baker-street, and Paddington, was extended to Willesden. Bridges and tunnels for junctions between new electric lines and existing lines to Euston and Broad-street are in progress, and the driving of the iron-lined tunnels under Primrose Hill is proceeding steadily, about half the length having been completed. An electric power-station and repair-shed at Stonebridge Park and six electric sub-stations are complete, and part of the plant has been installed. The equipment of new lines for electric traction between Willesden and Watford is in a forward state. Electrical equipment of the North London, Hampstead Junction, and the North and South-Western Junction lines, which form a through route between Broad-street and Kew Bridge and Richmond, is being proceeded with. The doubling of a portion of the Coventry and Kenilworth branch has not yet been completed. A down loop at Foleshill has been opened for traffic. A reconstruction of the passenger station at Nuneaton is being proceeded with, and portions of the buildings have been brought into use. A widening of the Chester and Holyhead line between Abergele and Llandulas has been opened for passenger traffic. At various places upon the system short branch lines and extensive groups of sidings have been carried out on Government account for the War Office and the Ministry of Munitions. An additional goods shed, offices, and other accommodation at Ellesmere Port on a London and North-Western and Great Western joint line have been completed and brought into use; this is the first instalment of a large scheme. The whole expenditure made by the London and North-Western Railway last year on capital account was 832,462*l.*; of this outlay 214,364*l.* was for rolling-stock, and 260,256*l.* for electric power-stations, &c. The electrification last year of certain London and North-Western suburban lines involved an outlay of 43,518*l.* Widening from Chalk Farm to Willesden Junction cost 105,911*l.* An advance of 143,500*l.* was made to the London Electric Railway Company. The London and North-Western Railway owns eight rail motor vehicles, of which seven are worked by steam power and one by petrol power.

The North-Eastern Company has made substantial progress with a reconstruction of the north entrance at the Hartlepool Docks; the work is, indeed, approaching completion. The amount expended last year by the North-Eastern Company upon lines opened for traffic was 250,066*l.* Docks, harbours, and wharves also involved an outlay of 204,665*l.* A further expenditure of 155,733*l.* was made by the North-Eastern Company on capital account in respect of the Hull joint dock. Works carried out last year (including dredging) in connection with existing docks cost 34,237*l.* The electrical equipment of the Shildon and Newport line has been completed. The North-Eastern Company owns eleven electric engines. It also owns five rail motor vehicles worked by petrol power; for trains worked by electric power the company has forty motor vehicles and fifty-five trailer vehicles.

Few important new works were carried out last year by the Midland Company. A further outlay of 59,376*l.* was made upon lines open for traffic; new lines involved an outlay of 5050*l.*, and 4127*l.* was devoted to widening and improving existing lines. Other capital expended last year was:—Plant and machinery, 5917*l.*; rolling-stock, 5917*l.* The aggregate outlay for rolling-stock to the close of last year was 17,951,001*l.*; for plant and machinery, 808,134*l.*; for steamboats, 469,716*l.*; and for electric power-stations, 7085*l.* At the close of 1915 the company owned 2283 steam locomotives and 69 electric locomotives and motors.

The Great Western Company has made progress with the construction of its Ealing and Shepherd's Bush line, the section of its Wolverhampton and Bridgnorth line between Wolverhampton and Kingswinford, its Clydach, Pontardawe, and Cwmgorse line, and its Trenance Valley line; but, in consequence of shortage of labour and difficulty in obtaining materials, the works have only proceeded slowly. At Paddington terminus additional platforms and lines on the arrival side are approaching completion. The amount expended upon capital account last year was 527,150*l.*, the aggregate outlay to December 31 being carried to 114,396,531*l.* The principal items of capital account expenditure last year were:—New lines and station enlargement at Paddington, 34,623*l.*; additional accommodation near Bristol, 36,901*l.*; Small Heath goods dépôt, 33,567*l.*; Neath loop, 57,174*l.*; Pennar branch widening, 49,459*l.*; Clydach, Pontardawe, and Cwmgorse line, 44,835*l.*; and additional rolling-stock, 85,320*l.*

The expenditure on capital account of the Barry Company last year was 38,153*l.*; of this sum, 10,248*l.* was expended upon the company's railways, and 27,860*l.* upon docks, harbours, and wharves, in which it had previously invested 3,003,268*l.*

In consequence of the scarcity of labour occasioned by the war, the Central London Company has made only slight progress with the construction of an extension between Wood Lane and Ealing Broadway. Further capital expenditure was made by the Central London Railway in 1915 to the extent of 35,440*l.*; of this amount, 21,977*l.* related to new lines, 7581*l.* to lines opened for traffic, and 3510*l.* to rolling-stock. The cost of electric train-working upon the Central London Railway in 1915 was 55,028*l.*, as compared with 45,171*l.* in 1914. There was an increase, however, last year of 26,967*l.* in the company's net income. At the close of last year the company owned two electric locomotives, 64 motor-cars, 60 controlled trailer-cars, and 111 trailer-cars.

The Great Central Company proceeded last year with works for widening the line at Godley, a goods dépôt at Blast-lane, Sheffield, and the reconstruction of Barnetby station. In connection with the Woodhead Tunnel a further ventilating shaft has been completed and has proved beneficial. The Keadby deviation line is approaching completion. The Doncaster and Thorne line has been delayed by the scarcity of labour. The permanent way, except for a short length, has now been completed, and the rebuilding of stations at Barnby Dun and Stainforth is almost finished. A commencement has also been made with the construction of sidings to connect a colliery now being sunk near Stainforth station. Considerable progress has been made with a reinforced-concrete extension at No. 2 fish dock at Grimsby. The Gowdall and Braithwell line will be completed at an early date, and a duplication of the Mansfield line will probably be finished for goods and mineral traffic by the end of this month (March). Widening works carried out last year by the Great Central Railway at various points upon its system involved an outlay of 157,184*l.*

The Great Eastern Company had no important new works in hand last year, but 46,616*l.* was expended upon lines opened for traffic; in this total works at Bishopsgate figured for 17,667*l.*, and Lowestoft Harbour for 11,815*l.*

The expenditure made by the Great Northern Company on capital account last year was 332,321*l.*, of which 196,502*l.* was for new lines, and 27,735*l.* for lines open for traffic. In the new lines outlay the Enfield and Stevenage loop (second and third sections) figured for 180,473*l.*; the Scrooby and Harworth line for 66177*l.*, and the Waltham and High Dyke line for 9412*l.*

The construction of a joint railway, vested in the Hull and Barnsley and the Great Central Companies, has been impeded by shortage of labour and other causes occasioned by the war; but the works are now practically completed. The additional capital expended by the Hull and Barnsley Company last year was 237,348*l.*, of which 66,000*l.* related to lines open for traffic and wholly or partly owned by the company, and 164,028*l.* on docks and wharves; in this latter total the King George Dock figured for 156,226*l.*, Salt End jetty (Hull and Barnsley and North-Eastern joint) for 8413*l.*

The additional capital expenditure of the London, Brighton, and South Coast Company last year was 87,711*l.* The outlay was somewhat larger, but it was reduced to the extent of 15,029*l.* by a sale of carriages and trucks. The largest item in the new expenditure incurred last year was 99,823*l.* for the electrical equipment of certain suburban lines.

The capital expenditure last year made by the managing committee of the London, Chatham and Dover and the South-Eastern Companies was 125,108*l.*, as compared with 316,694*l.* in 1914. In view of the abnormal conditions now prevailing in the railway world, the committee has restricted capital expenditure to works absolutely necessary for conducting traffic. A subsidence between Folkestone and Dover occasioned by a slip of adjoining land in consequence of an abnormal rainfall has temporarily closed the line between those towns. In view of existing restrictions on traffic and the necessity of curtailing national expenditure, the directors consider that it is not desirable to commence the restoration of the line at present. Dover Harbour involved a further charge on capital account last year of 68,775*l.*

Electric trains are now running over a large portion of the London and South-Western Company's lines in the Metropolitan area. A power-house has been completed at Durnsford-road, Wimbledon, and sub-stations at various other places have been brought into use. Electric trains have been running since October, 1915, between Waterloo and Wimbledon *via* East Putney, and last month a service of similar trains was commenced on the Kingston roundabout line *via* Malden and Richmond and on the Shepperton branch. An expenditure of 327,616*l.* has been made upon the electrification of suburban lines. The work of enlarging and improving the Waterloo terminus has made further progress, and there are now eleven new platforms in use on the south side of the station, with a new central roadway for cabs and other vehicles. Another block of offices is approaching completion, and some of the platforms on the north side of the station have been altered in conformity with the general scheme. A new down line for Hampton Court trains between Surbiton and Thames Ditton has been completed and brought into use.

The expenditure made last year on capital account by the Metropolitan District Company, after allowing for sundry credits arising from sales of surplus land and rolling-stock, was 17,069*l.* In this total additions and improvements to electric power-stations figured for 2538*l.* At the close of last year the company owned six electric locomotives, six motor-cars of a uniform class, six motor-cars of a composite class, 104 trailer-cars of a uniform class, and 118 trailer-cars of a composite class.

The expenditure made by the North Staffordshire Company last year on capital account was 8020*l.*; the items represented by this total were of no general interest.

The capital expenditure of the Rhymney Company last year was 19,942*l.* A new section at Caerphilly cost 2970*l.*, and widenings involved an outlay of 14,997*l.*; the most costly of these widenings was that from Ystrad to Pwllypant.

We have already dealt with the Lancashire and Yorkshire Company's electrification work on a previous occasion.

There was not much construction of importance in Scotland last year. Electrification has made little progress so far North, but the Caledonian Company has expended 29,832*l.*, the Glasgow and South-Western Company 3870*l.*, and the North British Company 34,962*l.* upon electric power-stations. The heaviest outlay of the Caledonian Railway on capital account was made in the reconstruction of the Carstairs station, and the remodelling of a line in the neighbourhood. The capital account outlay of the Glasgow and South-Western Company last year was 35,949*l.*, of which 20,632*l.* related to lines open for traffic. A sum of 14,778*l.* was expended upon an extension of the Potterhill and Barrhead branch. The Great North of Scotland Company expended 11,889*l.* in 1915; the heaviest outlay was made on Aberdeen joint passenger station. The Highland Company is completing sidings for timber traffic at Inchmagrancahan, between Dunkeld and Dalguise; additional capital for goods traffic has also been expended at Inverness to meet the requirements of the War Office. Sidings have further been laid down at Nigg, Invergordon, station and harbour, and Dingwall station, and a new passenger platform has been provided at Thurso. Additional capital was expended by the Highland Company last year to the extent of 9181*l.* A new engine-shed at Galashiels has been completed by the North British Company, and is now in use. An embankment for doubling the harbour branch at Granton has been completed, and a start has been made in laying down the permanent-way. An embankment, required in land reclamation, for additional sidings is making good progress. Trouble has arisen in connection with the working of Methil dock-gates, and investigations are proceeding with the view of ascertaining the cause.

It remains to add a few words with respect to Ireland. A beginning has been made by Irish companies with the use of electric power, but not much has been done at present. The Irish Great Northern Railway had expended, to the close of 1914, 20,126*l.* upon electric power-stations, and the Great Southern and Western Company had made a similar expenditure to the same date of 20,075*l.* No further capital was expended under this head by either company last year. The Irish Great Northern Railway expended capital in 1915 to the extent of 100,674*l.*; of this total, 46,025*l.* related to lines open for traffic and 54,944*l.* to rolling-stock, the difference being made good by sundry credits. The Great Southern and Western Company expended capital last year to the extent of 34,526*l.*, of which 12,478*l.* related to lines open for traffic and 17,837*l.* to additional rolling-stock. The outlay made upon existing lines occurred principally at Dublin, Cork, and Limerick. The new capital expenditure of the Midland Great Western Company last year was 2905*l.* Nothing was included in this total for electric power-stations, upon which 1145*l.* had been expended to the close of 1914.

POWER-DRIVEN TOOLS ON BOARD SHIP.*

By J. H. THOMSON.

IT might be thought that in the present age of machinery there would be little need to plead for up-to-date power-driven tools for executing the every-day mechanical work on board a modern steamship; yet the majority of ships will be found deficient in this respect, many possessing no power-tools whatever, others only a non-descript lathe put on board with considerable disregard of the probable requirements, size of ship, &c., and of the large range of work which can be economically carried out, given suitable and suitably-equipped tools.

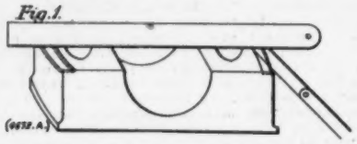
Any repair that can be efficiently carried out on board ship by the ordinary staff, without entailing the neglect of other duties and without entailing any overtime work, will cost anything from 75 per cent. and upwards less than such repair would cost ashore. For there are no extra wages to pay for such repair; there is no charge for the use of shore machinery; the profit required by the shore firm is saved; much scrap material which usually goes ashore for a very small return can be profitably worked up on board; there is an enormous saving in the time taken to execute the repair, a saving which in some cases would avoid the ship being detained in port; owing to the quickness and ease with which the work can be done, the machinery will be kept in better repair, as the ship's staff will have more time to devote to it; there will be a saving in the bill for files and other hand-tools used on board; and last, but not least, it will tend to minimise that fruitful cause of discontent on board ship—overtime.

To take a simple illustration of everyday routine work; suppose a 3-in. diameter by 2-in. wide bearing wants stripping, the amount of metal to be removed—ascertained in the usual way by leads—is $\frac{1}{16\frac{1}{2}\frac{1}{2}}$ in.; it could be put in the lathe, the amount required taken off to within $\frac{1}{1000}$ in., a true plane surface left, parallel with the opposite plane surface of the bearing, or parallel with the bearing itself, as may be required, sharp edges and rags removed—all in well under half-an-hour, with a minimum of physical labour by anyone with a slight knowledge of turning. In the vice, with a good file, the same job would take from 1 to 1½ hours, and, given a good tradesman, might have the required amount off to within $\frac{1}{1000}$ in., and in that time have an approximately plane surface, approximately parallel with the other surface of the bearing. With a poor tradesman there might be $\frac{1}{1000}$ in. or more of error in the parallelism of the two surfaces, and the new surface might resemble the Bay of Biscay on a rough day more than a true plane. In contrasting these two methods of doing the same job, remember that such a job has often to be carried out in an engine-room at a high

* Paper (slightly abridged) read at the Institute of Marine Engineers, Tuesday, January 11, 1916.

temperature, particularly so in the tropics. Doing the job in the lathe it has been a pleasure to the engineer, and he is practically as fresh after its completion as he was before he started. Doing it in the vice is mere mechanical drudgery, and the engineer is wet with perspiration and has lost a considerable amount of energy. In passing, a simple method of taking off exactly the right amount of metal in the lathe may be given:—Face up only about a quarter or less of the surface to be stripped, until, when laying a good straight-edge across the old surface, the required feeler will just slip in between the straight-edge and the new surface, after which the remainder of the old surface can be faced down to the same plane (see Fig. 1).

Fig. 1.

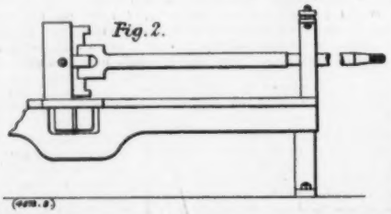


An illustration of common repair: The valve-spindle of a steam stop-valve is broken on the day of sailing. With a power-driven lathe on board, and a small stock of various sizes of brass rod, such a spindle could be replaced in about four hours, possibly less if it so happened that there were any old valve-spindles on board which could be worked up for the job. Without a lathe and with the necessity to send the spindle ashore to be made good, the time lost may be anything from a half-day upwards.

The minimum power-driven tools advocated on board a ship are: a lathe, a drilling-machine, and a high-speed grinder. These tools should be so arranged that each can be used independently of the others, or that all these can be in use simultaneously. It will be most convenient if the three machines are grouped together, so that all may be driven off the one counter-shaft, fitted in the usual way with driving and loose pulleys. For driving the counter-shaft an electric motor complete with starting switch, &c., will be required, the power of the motor depending upon the size of the tools that it is proposed to instal; one of 2½ horse-power should be ample for all ordinary requirements. A point which might be considered is whether the motor might not be fitted so as to be capable of assisting the lathe gearing in getting the required slowness of speed for turning a job of large diameter; such a job being of infrequent occurrence, there would be no objection to running the counter-shaft temporarily at a reduced speed. Getting the lathe to revolve slow enough is sometimes a bit of a problem on board; it can occasionally be solved by running the dynamo at a reduced voltage.

The Lathe.—It is difficult to fix definitely the size of the lathe that should be fitted on board ship, and the point should be one that will bear discussion; the suggestion is put forward that the aim should be to have a lathe which, with the gap removed, would be capable of dealing with the high-pressure junk-ring, the high-pressure piston being the one which usually gives the most trouble from wear, &c.; and for length capable of dealing with any of the main-engine valve-spindles, not that it is thereby implied that the valve-spindle should be accommodated between the lathe centres; it will be sufficient if, by the aid of a fixed stay (Fig. 2), that part of the

Fig. 2.

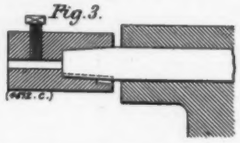


spindle which works through the neck bush, stuffing-box, gland, and guide can be efficiently dealt with. Space in a ship for a lathe of such size is not always obtainable, but with a little contriving it should be managed, except in very small boats, where the length may require consideration. A suitable position in a turbine-driven ship is often found in the shafting space, which usually extends right across the engine space; there the lathe, drilling-machine, and grinder can be ranged along the ship's side, using the ship's frames for the purpose of attaching countershaft brackets, motor, &c. The forward starboard side is usually the more suitable, thus leaving the ends of the shears clear for any extra long job to overhang; this point should also be kept in mind if the lathe is placed in the engine-room, as one often sees the end of the shears close up against the ship's skin, which renders the turning of a long job impossible. If the space is so limited that the end of the shears cannot be left clear, then they may abut on a hold or bunker bulkhead, which can have a circular hole cut in it in line with the lathe centres, such hole being made water-tight with a covering plate. This means that a time must be selected for doing any job which is extra long, when the bunker is clear of coal, or the hold of cargo. It may be mentioned that such a hole, by bolting a suitably shaped piece of wood to it, may be utilised as a fixed stay.

There is one point that must on no account be lost sight of in selecting a position for these tools. The space selected must be well ventilated, and cool enough at all times, even with steam on the main engines and the ship in the tropics, for a man to work in comparative comfort. The speed at which the ship's lathe can be driven requires more consideration than it usually gets; for seeing that there is only the one machine, one would think it stood to reason that it was necessary it should be capable of a very much larger range of speed than would be the case in shop practice. Thus, if the suggestion that the lathe should be capable of dealing with the junk-rink be accepted, then it follows that the lathe-spindle should be capable of being driven from a speed suitable for such ring up to the speed suitable for turning a small-diameter brass pin; and if the suggestion made later on regarding the supplying of one or two emery wheels for use in the lathe be carried out, then the lathe-spindle should be capable of a higher speed still—say 1500 revolutions per minute—which is suitable for a 14-in. diameter wheel.

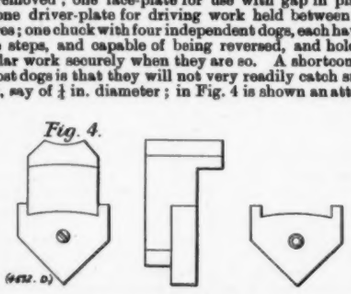
The ship lathe must be capable of cutting screws of all the standard pitches, and it may require to have one or two odd wheels for bastard pitches, if the engine-builder happens to be one of those who use bastard threads—a practice resorted to in order to compel the user to come back to the maker for renewals. The usual compound saddle-rest is required with cross-feed, &c. Quadrant should be marked off in degrees. The moving head-stock should have a cross-adjustment for purposes of alignment or turning up tapers. A suggested fitting for the moving head-stock which would be of great use is a drill-chuck, which would be attached to the moving cylinder of the head-stock, the boring of holes in work which is attached to the running spindle being of much more frequent occurrence than of that in which the drill is attached to the running spindle. Drills are sometimes supplied capable of being placed in the taper hole which holds the fixed centre or a special drill-holder; but the practice is not good, as the hole gets damaged, and so renders the fixed centre shaky or out of alignment. A suggestion for a holder is given in Fig. 3, which is self-centring and

Fig. 3.



free from shake, and can be detached by drawing in the cylinder by means of its screw, when the holder will abut on the barrel, and be forced off; a sunk feather is fitted to the holder, engaging in a keyway on the under side of the cylinder-end. The attachments for the running spindle will consist of:—One large face-plate for use with gap removed; one face-plate for use with gap in place; and one driver-plate for driving work held between the centres; one chuck with four independent dogs, each having three steps, and capable of being reversed, and holding circular work securely when they are so. A shortcoming of most dogs is that they will not very readily catch small work, say of ¼ in. diameter; in Fig. 4 is shown an attach-

Fig. 4.



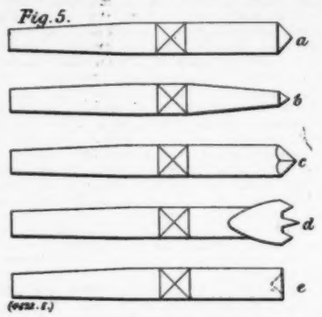
ment which will be found useful in this connection. Any one wishing to use it should make a wooden pattern a neat fit for the dog, and get four forged off it in tool steel; true up one flat surface of the forgings and fit them to the dogs; make sure when boring the holes and fitting the pins that the strain when screwing up the job will not come on the set-pins; the set-pins will last better if they are also made of tool steel. After the forgings have been fitted to the dogs, true up the sides of the V-shaped portion until the four points meet in the centre of the plate; the dogs are lying in a true circle, and the sides of the V-shaped portions form true radii of a circle; the front faces of the segments may be faced up with the chuck running on the lathe spindle. The V-shaped portions should not come to absolute points, but be left about $\frac{1}{16}$ in. wide; a small rack, consisting of a piece of ⅛-in. plate with four tapped holes to take the set-pins, is desirable to hold pins and segments when not in use.

There should also be supplied one drill-chuck which will hold the drills supplied to the ship; this may be one of the numerous small self-centring grip chucks, or a chuck with a plain parallel hole, say ⅜ in. in diameter, if the drills are, as is very common, forged from ⅜-in. round tool-steel bar; one fixed stay, which can be bolted down to the lathe shears; one running stay, which can be attached to the saddle—those with adjustable metal dogs are more useful than those requiring the fitting of various size wooden blocks; one hand-rest for wood-turning tools.

Fig. 5 shows the lathe centres required. Two ordinary pointed centres. One ordinary pointed centre with end of reduced diameter for small work. One cutting centre. Two or more driving centres for wood-turning. One hollow centre (optional). A list of tools is given of the ordinary form, ½-in. or ⅝-in. square-section common tool-steel, this steel being selected, as the many special self-hardening steels require an experienced tool-smith to deal with them; and while tools made of such steel could be dressed ashore, there is always the possibility of these getting broken when away from port and requiring to be redressed by the ship's staff.

Tool List.—Three ball-point roughing tools, two for iron, one for brass; two right-hand side-cutting tools, one for iron, one for brass; two left-hand side-cutting tools, one for iron, one for brass; one spring scraper; one right-hand knife-tool; one left-hand knife-tool; two Whitworth standard-thread screw-cutting tools, one medium, one small, and both to be dressed as right-hand tools; three parting or square thread-cutting tools, of width, say, $\frac{1}{16}$ in., ⅛ in., ¼ in.; five inside screw-cutting tools, to correspond with outside screw-cutting tools; the smaller size V-thread and the $\frac{1}{16}$-in. square thread to be capable of cutting a thread in a ½-in. hole. In the event

Fig. 5.



of the shifting headstock not being fitted to hold drills, one drill-holder suitable for fixing in the tool-rest. A set of inside and outside combs.

Other tools may be added from time to time as may be required, but with the foregoing outfit any ordinary job can be tackled. In getting tools made or dressed for ship's use, it should be remembered that they will be principally used for light duty—that is, taking a light cut or skimming off work that has been previously machined, and they can therefore be dressed of lighter shape than would be the case for shop work; further, the facilities for grinding tools on board being usually of the most crude description, the under side of the tools should be cut well back, so that there may be as small a surface of steel to grind as possible. Fig. 6, A, shows a ball-point roughing-tool as used in the shop; B a similar tool for light duty in a ship's lathe, when it will be noticed that the surface to be ground (a) when the tool requires sharpening is only about one-third in tool B of what it is in tool A.

The Drilling-Machine.—For ship work a machine which will bore holes from $\frac{1}{32}$ in. up to 1½ in. is required, and it must therefore have the range of speeds and power required for such sizes; it will not matter if the speed is not quite so high as boring a hole of $\frac{1}{32}$ in. permits, but it must be able to revolve slowly enough, and have the requisite power and rigidity for the 1½-in. hole; a speed ranging from 30 revolutions per inch to 300 revolutions per inch per minute should be obtainable. When space can be had, a useful type of machine is the one which has the drillings-pindle and its driving and feed-gear mounted on a short cast-iron pedestal or column, a double bracket,

Fig. 6.

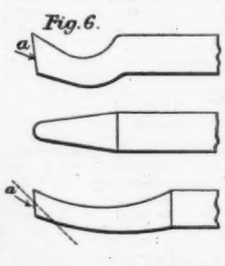
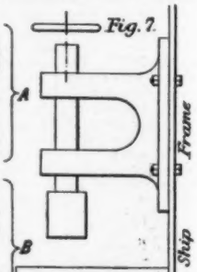


Fig. 7.



capable of swinging round, being raised or lowered, and clamped in position on the column. One end of the bracket supports a round table capable of revolving on its axis, and of being clamped; the other end consists of small shears, on which slides a parallel vice. This is a well-known type of machine familiar to all engineers, and made by practically all the well-known tool-makers. It has the further advantage that the brackets, when swung at right angles to the spindle, leave the floor space clear for putting any extra large job under the spindle.

When space is not available various modifications can be made; thus, instead of a double-swing bracket a single one can be used, allowing the machine to go close against a bulkhead, or the ship's side, when the flat revolving table should be retained and a parallel vice supplied, which can be bolted on top of the same. The advantage of the vice fitted on the shears is the clearance which is available under the vice; the limit to the length of the work which may be held being the floor underneath. A

ship's frame can be utilised instead of the cast-iron column, the drilling-spindle and its gear being secured to the frame at a suitable height; the table could consist of an ordinary good-sized cast-iron knee-plate, capable of being bolted to the frame at various heights, or of being removed to allow the job to sit upon the floor. A parallel vice should be supplied, which will be suitable to attach to the table. Fig. 7 is a rough sketch of a drilling-machine attached to the ship's frames; in both instances all driving, feed-gear, &c., is omitted.

The drills for the machine are the next consideration. Should they be twist, flute, or common, should they have parallel round shanks, taper round shanks, or taper square shanks? The ideal would be to have two complete sets of drills: the twist or flute for use in the machines, and the common drills for use in the ratchets or machines; failing this, choice must be made of the one kind for all purposes. The drill which can be most easily made, repaired, and ground, is the common drill forged from plain $\frac{3}{8}$-in. round-bar tool-steel, with a flat at the one end to take the point of the set-pin (Fig. 8). The sockets of the ship's ratchets should suit this, or a loose socket with square tapered male end (Fig. 9) and round $\frac{3}{8}$-in. parallel female end be supplied; such sockets are not very difficult to make, and two or three of various lengths are most useful for ratchet work, and will often save a lot of time being spent in hunting up and fixing packing. The set-pins for these sockets should be of tool-steel, with the cheese points slightly tempered, each socket having two set-pins, one with a square head, the other of a grub-screw shape; the latter is only for use when there is not clearance room for the one with the square head. If flute or twist-drills are to be supplied, the flute shape will be the more useful; they are more easily ground, and they are more efficient for use in reamering out a hole parallel and true to size, at which class of work a twist-drill has a great tendency to draw itself into the work, seize, and snap. In attempting to reamer a hole with a twist-drill it usually pays to plug up the original hole first with hard wood or brass.

The sizes of drills should range at least from $\frac{1}{16}$ in. to $1\frac{1}{4}$ in., advancing by $\frac{1}{64}$ in., with four extra drills for $\frac{3}{8}$-in., $\frac{1}{2}$-in., $\frac{5}{8}$-in., and $\frac{3}{4}$-in. tapping sizes, and one good large countersink point, making 27 drills in all. Better still if the sizes range from $\frac{1}{16}$ in. to 1 in. by $\frac{1}{32}$ in., and from 1 in. to $1\frac{1}{2}$ in. by $\frac{1}{16}$ in., with countersink point, making 36 drills in all. There remains the question of sizes smaller than $\frac{1}{16}$ in.; for this purpose a good method

Fig. 8.

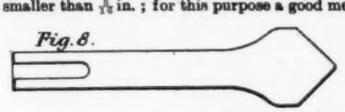


Fig. 9.

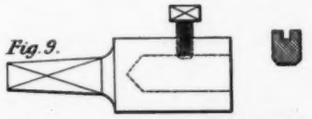


Fig. 10.

is to have them forged from $\frac{1}{16}$-in., $\frac{3}{32}$-in., and $\frac{1}{8}$-in. square tool-steel rod, a short length, say 2 ft. of each size, being also supplied to provide for any breakage or odd length drill that may be required. Steel rod of this size and section requires the minimum of forging, and the square section provides a most efficient grip for the ordinary shark-jaw chuck with which the American brace is usually fitted; for use in the power-driven drilling-machine a chuck should be supplied. A useful chuck for the drilling-machine and lathe can be made by making a male part, as shown in Fig. 10, to suit the shark jaws and outer nut removed from either the American or the wood brace.

The Grinding-Machine.—Why, it may be asked, should the engine-room of a modern ship, a space full of intricate

Fig. 11.

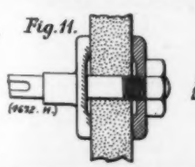
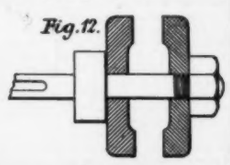


Fig. 12.



machinery, have placed in it a dirty, inefficient, manual-power grindstone? The most suitable grinder for a ship should open up some discussion and suggestion from those who have expert knowledge of the subject. A machine with a 12-in. to 14-in. by $1\frac{1}{2}$-in. wet wheel on one end of the spindle, and a similar-sized emery-facer on the other end, with suitable rests, &c., should prove a useful and satisfactory machine for ship use. An attachment should be supplied for grinding twist or flute-drills. Those who have to contend with the old-fashioned grindstone will find the expedient of getting an emery-wheel and using it in the lathe a welcome help; a sketch of such a wheel fitted on a suitable spindle to fit the drill-chuck is given in Fig. 11. In ordering a wheel for this purpose, get as large a diameter wheel as the lathe will accommodate with the gap in place, in order to get a good peripheral speed; a small wheel at the usual fastest lathe speed is not of much utility. It should be possible to provide a lathe with a sufficiently high speed for driving an efficient wheel of medium size, and this might be done when, for reasons of want of space, a grinder could not be installed. The drawbacks to the emery-wheel being used in the lathe are the difficulty of keeping the wheel running true, and the grit that tends to get into the spindle bearings and under the saddle; with due care the latter can be much minimised. As the spindle in Fig. 11 requires a special forging, a sketch is given in Fig. 12 of a construction that can be carried out on board ship. The spindle is turned out of a good-sized piece of steel, in order to get as large a collar as possible; the washers are made of $\frac{1}{4}$-in plate, one-third the diameter of the wheel, faced on one side sufficient for a collar and nut respectively, and recessed on the other side in order that they may grip the wheel at their edges; or, instead of recessing, a ring, of $\frac{1}{16}$ in. of paper or fibre on either side will give the same result.

The Forge.—This may not be, strictly speaking, a power-driven tool, unless the term may be permitted if the blast is supplied from a power-driven fan; why it should not be so is difficult to understand, as the cost would be not much greater than supplying the usual hand forge, with which members are doubtless familiar, possibly painfully so. Seeing that the average steamer is provided with power-driven fans for the boiler furnaces, it should not be a difficult matter to provide a forge with an air-pipe led to it from a convenient fan trunk. The following are details of an expedient that was carried out:—The cyclone part of the forge was removed and the remaining cast-iron pan and tuyere on its stand were bolted down in a corner of the stokehold, immediately under a fan-trunk; some old 3-in. iron pipes, flanges, and elbows that happened to be on board were utilised to make a connection from the bottom of the fan-trunk to the tuyere; a thick asbestos millboard joint was put between two of the flanges, with a portion of the joint cut away and one bolt left out; in the space thus provided a bit of sheet iron of U shape was inserted, which acted as a valve. The result was an excellent forge, capable of melting cast iron, as was conclusively proved by the prompt disappearance of the tuyere; however, a new one protected by fire-bricks and fire-clay lasted better and gave most efficient service; a water-cooled tuyere of the usual type would, of course, be better still.

Still, a coal-forge is not the ideal fitting for a steamer; such would require to be smokeless or nearly so, able to be put in operation on short notice, and should be capable of heating up $\frac{3}{4}$ in. square tool-steel to white heat in a reasonable time—say 5 minutes. It is seldom that any larger job than this turns up on board, and if it did it could probably be dealt with in one of the boiler furnaces.

This paper has not covered the whole ground of power tools for a ship; there are many other tools which could be suggested, which would be most useful and not very costly; such as an arrangement for driving a hack-saw, a small shaping-machine, both of which could be arranged as lathe attachments; a portable electrically-driven driller which can be used in any part of the ship, the current being got from the nearest lamp-socket, &c. It is hoped that enough has been said to initiate a good discussion, and to induce members to give details of any useful contrivance they may have seen or evolved, and it is suggested that such details should refer to power-driven contrivances only, otherwise so large a subject is opened up as to be unwieldy. Possibly at some future time the author or some other member will take up the subject of the outfit of hand-tools for a ship. It should render available a large store of personal experience, both for the use of those who go to sea and have to use the tools, and for those who have to do with putting a suitable outfit on board.

The spindle and back washer are best if made in one piece, as this gives a greater rigidity to the back washer and so gives a truer running wheel; but if the fitting is ship-made, a spindle fitted with two washers will answer the purpose almost as well, making the back washer a good fit for the spindle, and providing the latter with as large a collar as possible. Fig. 12.

Details of an actual job carried out on board ship with the tool used may be useful, and will assist to demonstrate the point that to fit power-driven tools pays.

The job to be done was to face up all the water-valves and seats of a standard Weir's pump fitted with the usual group valves; in this case the pump had sixty valves and seats; the sixty seats were faced up in the drilling-machine in five hours; the sixty valves were faced up in the lathe also in five hours. To have "done them up" by hand in the usual ship fashion—filing, ground glass, emery, bath-brick, &c.—would have taken anything from 25 to 50 hours, and the result would not be nearly so perfect as those done in the machines.

JACKETED GAS-BURNER.—A new Teclu gas-burner is described by P. Verbeck in the *Chemiker Zeitung* of December 11, 1915. It is a Bunsen burner, which is provided with two concentric tubes, the air being sucked down through the annular space between the two tubes and reaching the flame from below in a preheated state. The connection with the rubber tube from the gas-pipe is made, as usual, in the base of the burner; the orifice of the horizontal gas-inlet tube can be closed more or less by the pointed end of a screw. Into the base is screwed a block which widens out to a disc; into this disc and its cylindrical shell the two burner-tubes and other parts are screwed. The block is perforated, and the perforation ends above in the nozzle for the gas-jet. The inner tube and, further out, the outer tube surround this nozzle, and both these tubes are opened out a little conically at their lower and upper extremities. The air-feed can be adjusted by lowering or raising the outer tube in its screw fitting. The arrangement is less complicated than it might appear, as all the parts can easily be fitted together. The advantage claimed is that a short, stout flame can be produced, which completely envelops the crucible to be heated; when a long, narrow flame is desired, a short, straight cylindrical tube is lowered into the inner tube, on whose edge it rests.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: The office of H.M. Trade Commissioner in Australia has forwarded specifications in connection with certain calls for tenders (as noted below) by the Victorian Government Railways. Sealed tenders, on the proper forms, will be received by the Victorian Railway Commissioners, Spencer-street, Melbourne:—(1) Up to 11 a.m. on April 12 for the supply and delivery of 2450 felt-body blocks, 8 in. by $3\frac{1}{2}$ in., with hole, for cars (Contract No. 29,778); (2) up to 11 a.m. on April 26 for the supply, delivery, and erection of a locomotive-boiler-washing plant for new engine-shed at Geelong (Contract No. 29,024); (3) up to 11 a.m. on April 26 for the supply and delivery of electrical equipment and accessories for sub-station for the Sandringham-Black Rock tramway (Contract No. 29,762). Tenders must be accompanied by a preliminary deposit of $\frac{1}{2}$ per cent. of the amount of the offer in the case of (1) and (3), and of 20*l.* in the case of (2). Local representation is necessary. The Sydney office of H.M. Trade Commissioner in Australia has forwarded a copy of a specification and tender form, &c., in connection with a call for tenders by the Metropolitan Board of Water Supply and Sewerage at Sydney, for the supply, delivery, and erection of a filtration plant at the Lower Dam, Cordeaux River, near Wollongong. The plant is to be capable of filtering, purifying, and rendering potable not less than 1,000,000 gallons of water per twenty-four hours when worked at the minimum head. The offices of the Metropolitan Board of Water Supply and Sewerage, 341, Pitt-street, Sydney, N.S.W., will receive the sealed tenders up to 2 p.m. on May 8. Each tender must be accompanied by a cash deposit of 10*l.*, or a marked cheque for that amount. The Commercial Intelligence Branch of the Board of Trade is in receipt of a copy of the New South Wales "Loan Estimates, 1915-16," for expenditure on public works and other services in the State, recommended by the Governor of the State for the consideration of the legislative assembly on December 9 last. The following items may be cited as of particular interest:—Harbour works and river improvements, 821,300*l.*; railway construction, 2,600,000*l.*; railway line additions, stations, and buildings, &c., 407,000*l.*; railway rolling-stock and equipment, 662,000*l.*; tramway construction and additions to workshops, buildings, power-house, &c., 265,000*l.*; railway and tramway stores and materials, 200,000*l.*; sewerage works, 287,000*l.*; water-supply works, 810,000*l.*; public buildings, 135,000*l.*; public abattoir, meat markets, &c., 200,000*l.*; irrigation, dam, and canal works, &c., 320,000*l.*

Canada: H.M. Trade Commissioner in Canada reports that the Town Council of Sault au Recollet (Quebec Province) is applying to the Quebec Legislature for power to raise a loan of 250,000 dols. (about 51,400*l.*) for the construction of a sewerage system, water supply and filtration plant in that town.

Russia: H.M. Commercial Attaché at Petrograd reports that the *Bulletin of Laws* (Petrograd) of January 19/February 1 published an Imperial Decree, dated November 29/December 12, 1915, authorising the town of Baku to issue a bond loan for 12,000,000 roubles nominal (about 1,266,700 at par) for the completion of the Baku-Shollarski water-works scheme. The loan is subject to the usual proviso that all orders for material and equipment must be given to Russian firms, unless special authority to make purchases outside Russia is obtained from the Ministers of the Interior and of Commerce.

Spain: The *Gaceta* notifies that sealed tenders will be opened on June 2 at the Negociado Quinto de la Segunda Sección (Material) del Estado Mayor Central de la Armada, Ministerio de Marina, Madrid, for the execution of various works at the naval bases of Ferrol, Cartagena, and Cadiz. The contract includes dredging, dock improvement works, construction of moles, shelters, &c., and the installation of electric capstans, &c. The *Gaceta* also publishes a Royal Decree approving the general plan for the construction of new roads in Spain, the cost of which will be provided for in the estimates of the Ministerio de Fomento. An appendix to the *Gaceta* gives the location and length of each section of road and bridges (the urgent works being especially distinguished) to be constructed in the Provinces of Albacete, Alicante, Almeria, Avila, Badajoz, Baleares, and Barcelona. The *Gaceta* further contains a Royal Decree authorising the Ministerio de Fomento to issue a call for tenders for the termination of the port works at Bouzas, in Pontevedra, the estimated cost of the undertaking being 327,647 pesetas (about 13,000*l.*). The *Gaceta* also notifies that tenders will be opened by the Municipality of Almeria on March 30 for the construction of a slaughter-house in that city. The estimated cost of the works is 128,817 pesetas (about 5150*l.*).

FURTHER ELECTRIFICATION OF SWEDISH RAILWAYS.—For the purpose of introducing electric traction on the East Central Railway it is proposed to exploit the power of the Svartan at Mjölarp. The question has been on the tapis some years, and a concession was granted, but the holder of the concession failed to comply with its conditions. The matter has now been taken up again, and a guarantee has been given to have the hydro-electric power station ready in 1920. The electrification of the Lund-Bjärred Railway is proceeding, although the State telegraphs have retarded the work in connection with the removal of telephone lines.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

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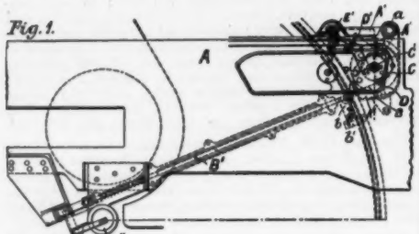
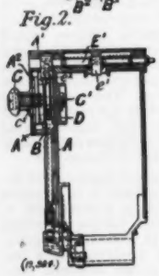
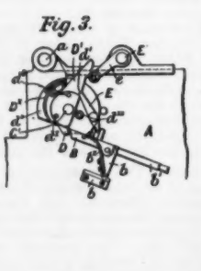
GUNS AND EXPLOSIVES.

17,984/14. Sir A. T. Dawson and G. T. Buckham, London. Automatic Guns. [11 *Figs.*] July 29, 1914.—This invention relates to automatic guns, particularly those of the well-known Maxim type, in which an angularly-adjustable "change-fire" device is provided for controlling an angularly-displaceable slip-pawl transmitting movement from the trigger to the sear, so that by suitably setting the device the slip-pawl can at will either be permitted to perform its slip function for firing single shots or be prevented from performing this function for firing automatically, whilst when the device is adjusted to the safety position the slip-pawl is prevented from transmitting movement to the sear of the firing mechanism. According to the present invention, the change-fire device is so constructed and arranged that during its setting to the automatic, single fire and safety position, it moves about the same axis as that of an angularly-displaceable member which is interposed between the trigger and the sear and upon which the slip-pawl connected to the trigger operates to fire the gun. A is the mechanism casing of the gun, and A^1 is the cover hinged to the casing at *a*. B represents the slip-pawl and C represents the change-fire device. D, D^1 represent the angularly displaceable member that is operated by the slip-pawl, this member being constituted by a two-armed lever. E represents the safety-lever. The slip-pawl B is controlled by a spring b^x, and is pivoted to a spring-controlled longitudinally-sliding rod B^1 arranged on the side of the mechanism casing. The end of the rod carrying the slip-pawl has a block *b* adapted to engage in a guide b^1 carried by the casing for the purpose of relieving the rod of strain. The other end of the rod is situated contiguous to the trunnions, and sliding movement may be transmitted to the rod



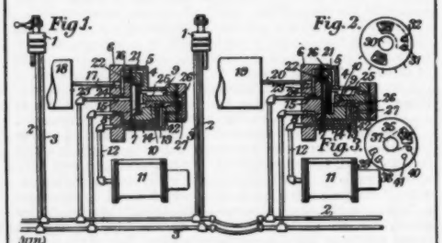




from the trigger by a bell-crank lever B^3 operated by a sliding-pin mounted co-axially within the trunnion-pin B^4 (Fig. 1). This trigger may be carried by the handle of the elevating hand-wheel. The slip-pawl operates upon one arm D of the two-armed lever D, D^1, whose arm D^1 is arranged in contact with an arm *e* carried by a spring-controlled spindle E^1; this spindle has another arm e^1, from which movement is transmitted in any suitable manner to the sear, which engages with a bent on the striker, the spring of which may be helical and arranged centrally within the striker. The bell-crank lever D, D^1 is controlled by a spring D^x, one end of which bears against the arm D and the other is connected to a plate d^x attached to one of the side-plates of the mechanism casing. The change-fire device C is in the form of a rotary member, or knob, which is capable of being retained in any one of three positions corresponding to "automatic fire," "single fire," and "safety." This knob has a pin, which is adapted to engage in one or other of three holes d^{xx}, d^y, d^z, of which the hole d^{xx} is formed in the plate d^x and the others are formed in the aforesaid two-armed levers D, D^1. The knob is controlled by a spring which tends to hold the knob in its inward position with the pin engaging in one of the holes. The two-armed lever is pivoted on an axis-pin C^1, upon which the knob is loosely mounted, and the slip-pawl engages with one arm of the safety-lever E, the other arm of which is adapted to co-operate with a notch d^1 in the boss of the two-armed lever to prevent the latter from being actuated and the gun therefore fired in the event of the knob being turned when it is set to "single fire." The slip-pawl B is disengaged from the two-armed lever D, D^1 (assuming that the knob has been set for "single fire," the pin being then in engagement with the hole d^y) by any suitable means, such as a cam at the back of the knob, which moves the slip-pawl out of contact with the two-armed lever when the knob is angularly displaced with the two-armed lever during "single-fire" operation; the pawl thus performs the slip action hereinbefore referred to. When the knob is set to "automatic fire," the pin is in engagement with the hole d^{xx} in the plate d^x, so that the knob is held stationary. As the cam at the back of the knob cannot come into contact with the slip-pawl when the lever D, D^1 is displaced, the gun continues to fire as long as the trigger or the like is held in the firing position. In this position of the knob a ledge thereon engages with the underside of the slip-pawl and prevents it from becoming released from the two-armed lever. When the knob is in the "safety" position the pin is in engagement with the hole d^z, and the two-armed lever D, D^1 is prevented from moving owing to the fact that a projection on the knob bears against a fixed stop c^3. The knob has a curved flange, whose periphery normally co-operates with a correspondingly curved rib A^2 carried by the mechanism cover A^1 in a position contiguous to the hinge-pin *a* of the latter. This curved flange is recessed at c^4, so that when the knob is in the safety position this recess comes opposite the recess A^2 on the cover, and permits the latter to be lifted about its hinge-pin, the rib A^2 moving in the recess which is concentric with the hinge-pin. In other positions of the knob this lifting of the cover is prevented from taking place, owing to the fact that the curved rib A^2 bears against the curved flange. The member *e* carried by the spring-controlled spindle E^1 may carry a lanyard arm e^x, by which the gun can be fired when necessary independently of the above-described firing mechanism. A cover A^x enclosing the knob and its associated parts must be removed before access can be had to the lanyard arm, so that the cover prevents improper use of this arm. The knob C carries a pointer c^x, and the cover A^x is engraved with three marks to indicate the three setting positions of the knob. The cover A^x is cut away to clear the pointer c^x when this cover is being placed in position. (*Sealed.*)

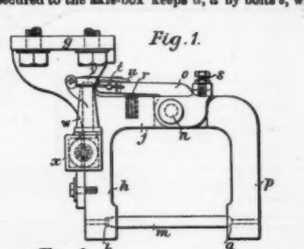
RAILWAYS AND TRAMWAYS.

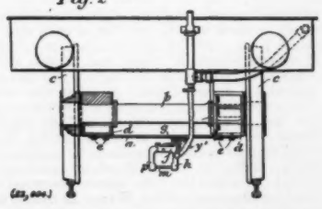
11,771/15. The Westinghouse Brake Company, Limited, London. Fluid-Pressure Brakes. [4 *Figs.*] February 17, 1915.—This invention relates to fluid-pressure brakes, and more particularly to that type known as the straight air emergency brake. In order to provide a simple and inexpensive equipment it has been proposed to employ only two pipes, a straight air train-pipe and an emergency train-pipe, there being no direct pipe connection from the main reservoir to the brake-valve, since the emergency train-pipe is designed to serve as the brake-valve supply-pipe as well as the ordinary emergency train-pipe. According to this invention, choke-plugs are provided in the brake-valve for limiting the rate of flow from the emergency train-pipe to the straight air train-pipe, the choke-plugs employed being provided with restricted passages to correspond with the particular volumes to be handled. In addition, there are two straight air service positions, one for single-car service and the other for two-car service, so as to provide for the different brake-cylinder volumes to be handled. The brake equipment for the motor-car may comprise a brake-valve 1 at each end of the car, having connection with the emergency train-pipe 2 and straight air train-pipe 3, the pipes leading to an emergency-valve device 4. The emergency-valve device may comprise a main body 5 having a cap 6 arranged for all pipe connections to the emergency-valve. Within the body 5 is a piston-chamber 7 containing a piston 8, and a valve-chamber 9 containing a slide-valve 10 adapted to be operated by the piston 8. Brake-cylinder 11 is connected by pipe 12 to passage 13 leading to the seat of the slide-valve 10, and straight air train-pipe 3 is connected to a passage 14, also leading to the seat of the slide-valve, the emergency train-pipe 2 being connected to a passage 15 which leads to a piston-chamber 7. A passage 16 leads to the valve-chamber 9, and on the motor-car is connected by a pipe 17 to the main reservoir 18, while on the trailer-car the auxiliary reservoir 19 is connected by pipe 20 to the said passage. A passage 21, having one



or more openings into the piston-chamber 7, communicates with the passage 16, and in the cap 6 this passage contains a removable choke-plug 22. A branch passage 23 also connects the passage 16 with passage 15 and contains a choke-plug 24, which on the motor-car has a restricted passage, but on the trailer-car is blanked. The piston-stem 25 of the piston 8 carries a small piston-head 26 at its inner end, and a passage 27 leads from the outer face of the piston-head to the straight air-passage 14. On the motor-car, the plug 24 has a restricted passage to permit equalisation of fluid from the main reservoir into the emergency train-pipe in the emergency position of the emergency valve, so that the brakes may be released while on the trailer-car, the plug 24 entirely closes communication through passage 23, so as to prevent back-flow in the emergency position from the auxiliary reservoir and the brake-cylinder to the emergency pipe. In the brake-valve, the rotary-valve seat is preferably arranged as shown in Fig. 2 of the drawing, with a port 28 leading to the straight air train-pipe 3, port 29 leading to the emergency train-pipe 2, atmospheric exhaust port 30 and first and second-service-position ports 31 and 32, which open to the straight air-port 28 through a cavity in the valve-seat. Removable choke-plugs are provided for regulating the rate of flow through the respective service ports 31 and 32. In some cases only one port 31 and choke-plug may be used. The rotary valve 35 of the brake-valve 1, the face of which is shown in Fig. 3, has a port 36 connected by a cavity in the valve with a central port 37 adapted to constantly register with exhaust-port 30 in the seat. The valve also has through ports 38 and 39 and through ports 40 and 41. In operation, with the brake-valve in quick-release position on the operating end of the car, and the other brake-valve in lap position, the straight air train-pipe is connected through port 28, port 36, and port 37 with exhaust-port 30, and the emergency train-pipe port 29 is open to through port 38 in the rotary valve 35, so that fluid under pressure from the emergency train-pipe can flow into the rotary valve-chamber, all the other ports being blanked. On the motor-car, fluid from the main reservoir 18 flows through pipe 17 and passage 21 to the piston-chamber 7 of the emergency-valve device 4, if the piston 8 is in release position, and fluid also flows through the passage 23 and the choke-plug 24 to the passage 15, so that the emergency train-pipe is charged with fluid under pressure from the main reservoir, and on the trailer-car fluid flows from the emergency train-pipe 2 to piston-chamber 7, and thence through passages 21 and 16 to the auxiliary reservoir 19 and valve-chamber 9. If there is no trailer-car, and it is desired to effect an ordinary straight air-service application of the brakes, the brake-valve handle is turned to the first-service position, in which the port 39 registers with port 31 and port 41 registers with emergency-pipe port 29. Fluid under pressure will then be supplied from the emergency train-pipe through port 29 and port 41 to the rotary valve-chamber and thence flows through port 39 and port 31 to the straight air-port 28 and the straight air train-pipe 3. From the straight air train-pipe fluid under pressure flows through passage 14, cavity 42, and passage 13 in the emergency-valve device 4 to the brake-cylinder 11. It will now be seen that the rate of flow to the brake-cylinder is controlled by the choke-plug in the first-service-position port, and by providing the proper-sized restricted port therein the flow may be maintained at a point not to exceed the capacity of the supply-ports in the emergency valve through which fluid is supplied from the main reservoir to the emergency train-pipe, so that the emergency train-pipe pressure cannot be reduced sufficiently in straight air operation to cause the accidental movement of the emergency-valve device. If a trailer-car is attached to the motor-car, then a straight air application is effected by turning the brake-valve handle to the second-service position, in which ports 38 and 39 register with ports 31 and 32 and ports 40 and 41 register with port 29. Fluid supplied from the emergency train-pipe to the rotary valve-chamber will now flow through both ports, 31 and 32, and the respective choke-plugs to the straight air train-pipe, and thence to the brake-cylinders on both the motor and trailer-cars. While there will now be a greater rate of flow from emergency train-pipe to the straight air-pipe, the increased tendency to reduce the emergency train-pipe pressure is compensated for by the back-flow of fluid from the auxiliary reservoir 19 on the trailer-car to the emergency train-pipe. (*Accepted November 10, 1915.*)

22,004/14. W. R. Sykes Interlocking Signal Company, Limited, and J. C. Sykes, London. Arresting Railway Trains. [4 *Figs.*] November 4, 1914.—This invention relates to improvements in means for ensuring the arrest, within a convenient distance of a predetermined point on the line, of a railway train or locomotive provided with pneumatic, vacuum, or other automatically-acting brakes, the means comprising a relatively fragile prop carried by the locomotive or train, and normally serving to prevent the application of the brakes, and adapted, on encountering an obstacle situated in the vicinity of the predetermined point, to be knocked away or broken so as to allow the brakes to come into operation. In accordance with the present invention, the prop is arranged horizontally under the engine or tender and transversely thereof, the ends of the prop being carried in sockets, one of which is formed in an arm depending from a cross-bar secured at its ends to the axle-box keeps or other parts, the height of which relatively to the rail-level is practically constant, whilst the other socket is formed in a lever pivoted to the cross-bar, and acted upon by means tending to maintain the lever in engagement with the end of the prop, said lever being adapted, when the prop is knocked away or broken, to open a valve connected with the train-pipe of the brake system, the valve being normally maintained closed independent of pressure through the lever. As shown in the drawings, a cross-bar *a* is arranged transversely of the engine under the axle *b* of the trailing-wheels *c*, *c*, and its ends are secured to the axle-box keeps *d*, *d* by bolts *e*, which at





one end pass through slots in the cross-bar *a*, whilst to its central portion is secured a bracket *g* carrying an L-shaped arm A *j*, whereof the part A extends downwardly and the part *j* extends towards one side of the engine. The part A of the arm is provided at its free end with a socket *k* for the reception of one end of the prop *m*. Pivoted by a pin *n* to the part *j* of the arm A *j* is an L-shaped lever *o p*, one part *o* of which corresponds with the part *j*, and extends transversely of the engine and between bifurcations in the part *j*, and the other part *p* corresponds with the part A of the arm A *j*, and is provided at its free end with a socket *q* for the reception of the other end of the prop *m*. The part *o* is influenced by a spring *r* housed between the bifurcations of the part *j* tending to maintain the part *p* of the lever *o p* in engagement with the end of the prop *m*, and the part *j* is provided with an adjusting-screw whereby the socket *q* in the part *p* may be prevented from disengaging from the prop *m*. The part *o* of the lever *o p* carries a cross-piece *t* adapted to engage beneath arms *u* on the covers *v* of the valves *w*. The valves *w* form parts of a valve-chamber *x* secured to the part A of the arm A *j*, and having a spigot connected by flexible tubing *y* with the train-pipe of the brake system to which the valves are adapted, when opened to permit the gradual admission of air. By a suitable and well-known variation of the valves *w*, the invention may be made applicable to a brake system working on the compressed-air principle. It is to be observed that the covers *v* of the valves *w* are normally held closed independent of the cross-piece *t* of the lever *o p*, and are only actuated thereby when the prop *m* is knocked away or broken. If desired, a whistle or the like arranged in the cab of the engine may be connected with the valves so as to be actuated by the escape or admission of air as above set forth. The obstacle (not shown) is preferably in the form of a cutter secured to a rocking-bar arranged transversely of the track, and connected with the signal-operating mechanism in the usual manner, whereby the cutter may be raised in the path of the prop *m*, the cutter, when raised, presenting a more or less sharp edge towards an approaching prop. (*Sealed.*)